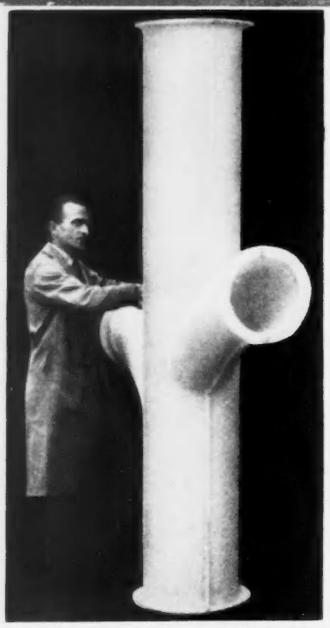
The Engineer

NOVEMBER 28, 1958 28 ESSEX ST., STRAND, LONDON, W.C.2 TWO SHILLINGS



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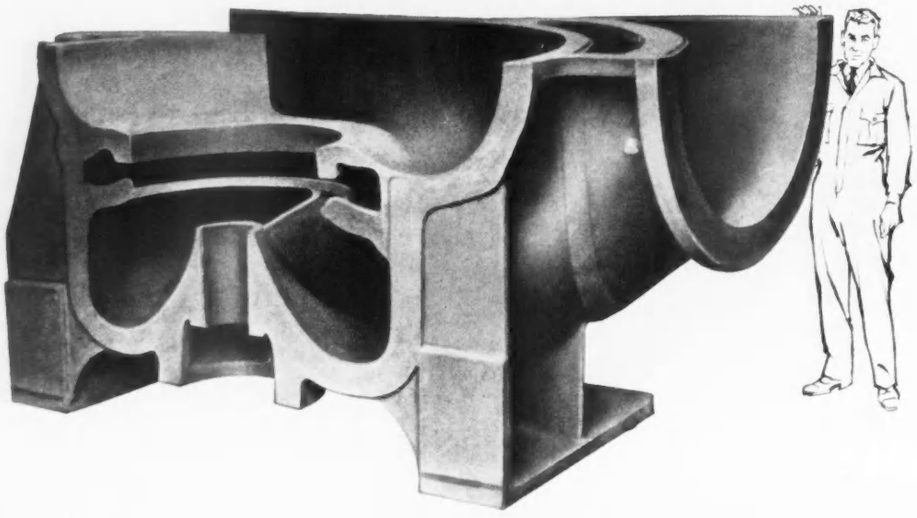
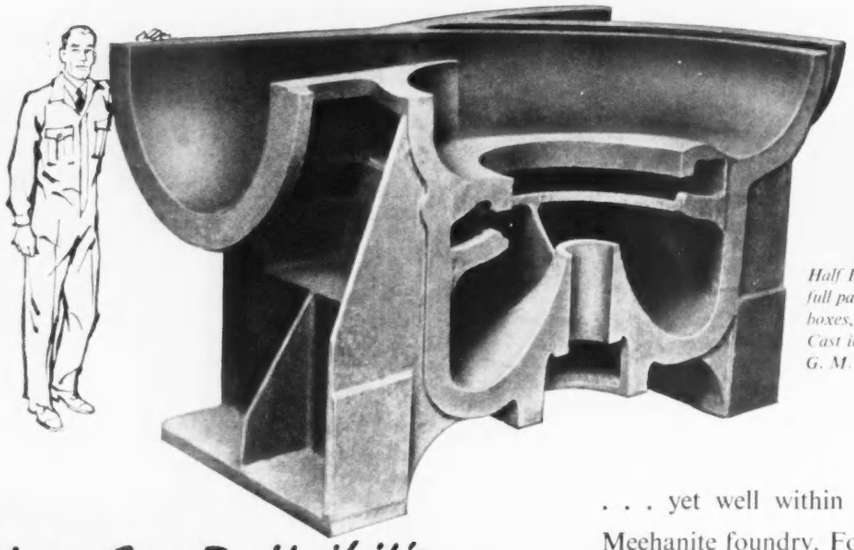


whichever way you cast it



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THE ENGINEER

Established 1856

No. 5366 **NOVEMBER 28, 1958** VOL. 206

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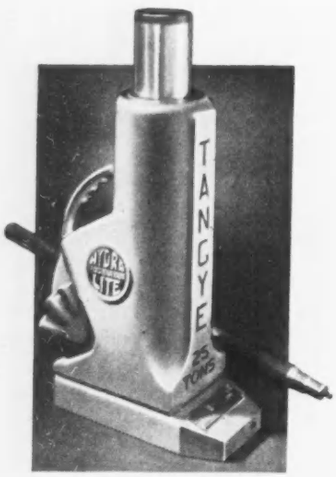
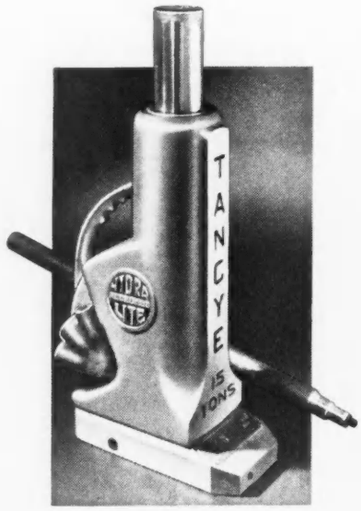
EXAMPLES FROM THE RANGE
OF

HYDRALITE

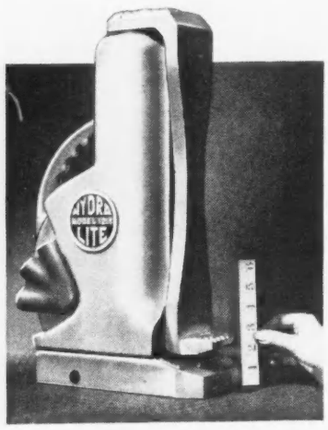
HYDRAULIC JACKS



25 tons capacity and 12" power lift with plain ram.



15 tons capacity and 12" power lift with screwed ram and retaining ring.



15 tons capacity and 12" power lift with claw attachment.

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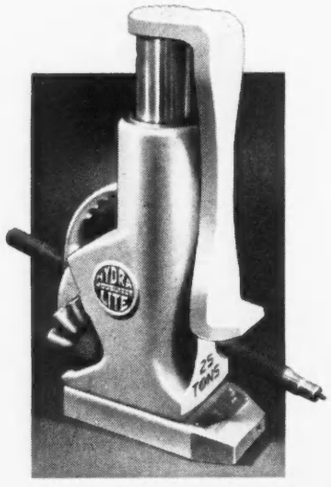
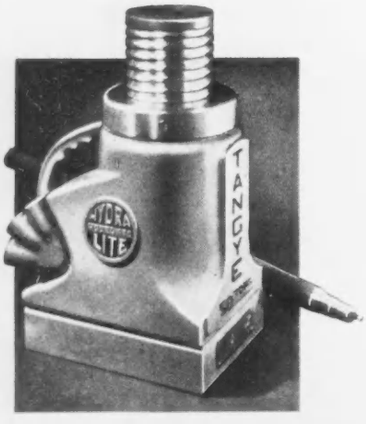
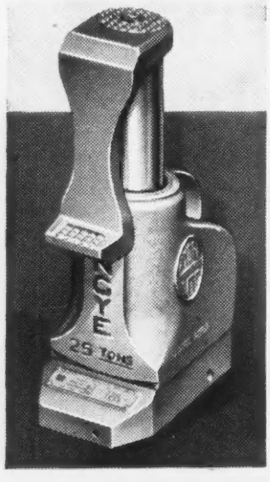


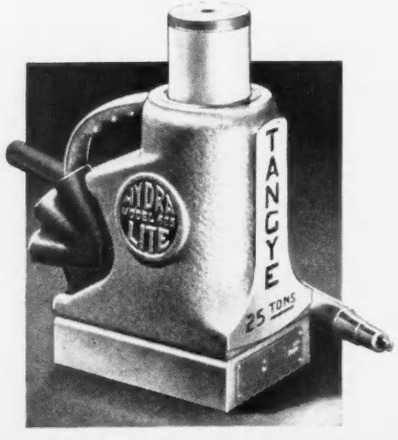
25 tons capacity and 12" power lift with claw attachment.



50 tons capacity and 6" power lift with screwed ram and retaining ring.



25 tons capacity and 6" power lift with claw attachment.



25 tons capacity and 6" power lift with plain ram.

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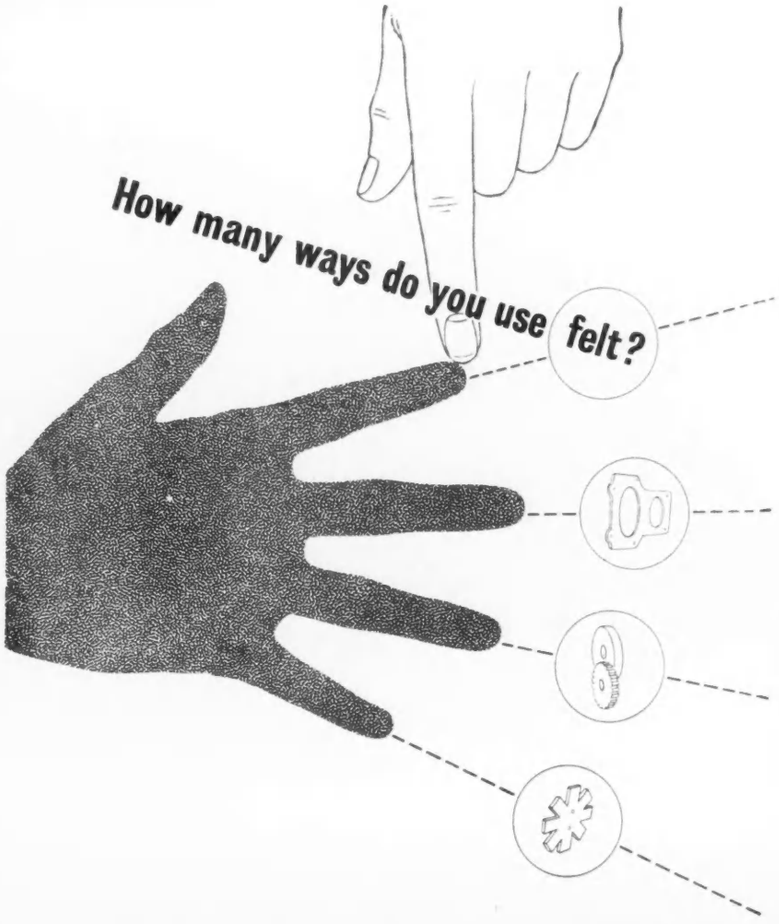

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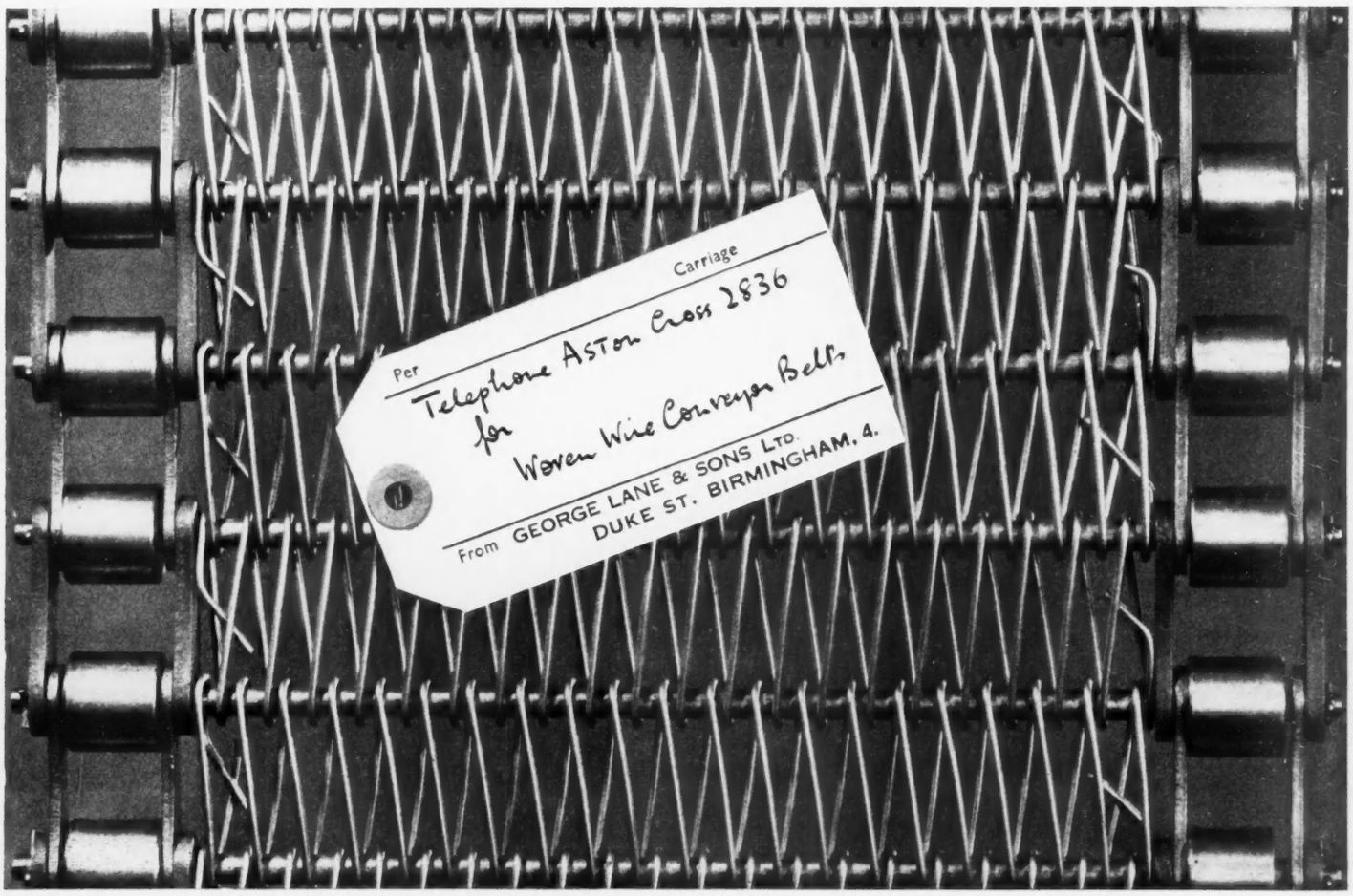

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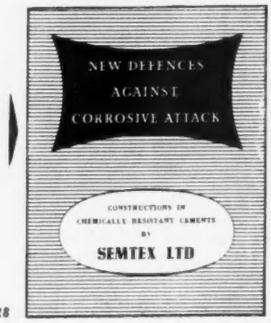

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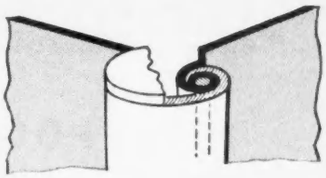

The detail shows the standard manganese bronze or non ferrous alloy hingeing strip arrangement. Curled edges of shutter leaves reinforced with $\frac{1}{4}$" dia. wire.

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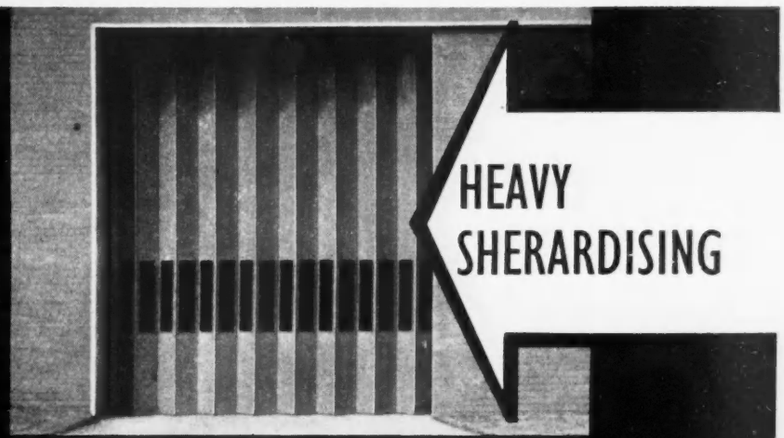

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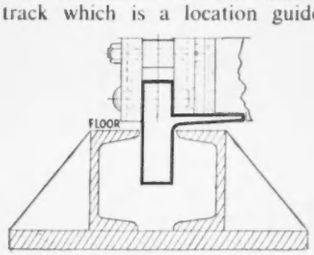

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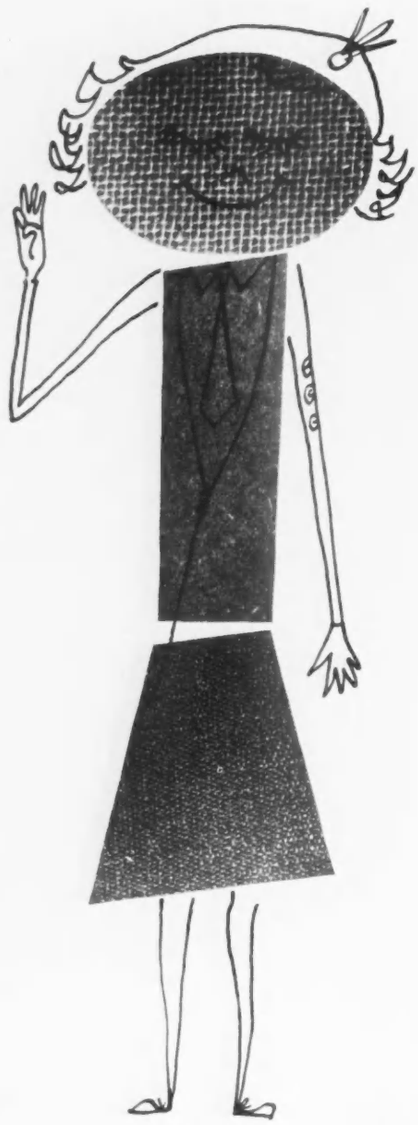

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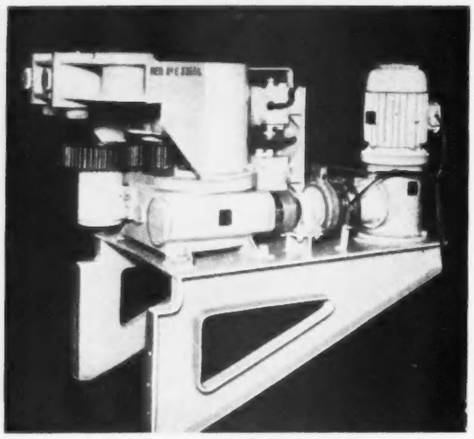

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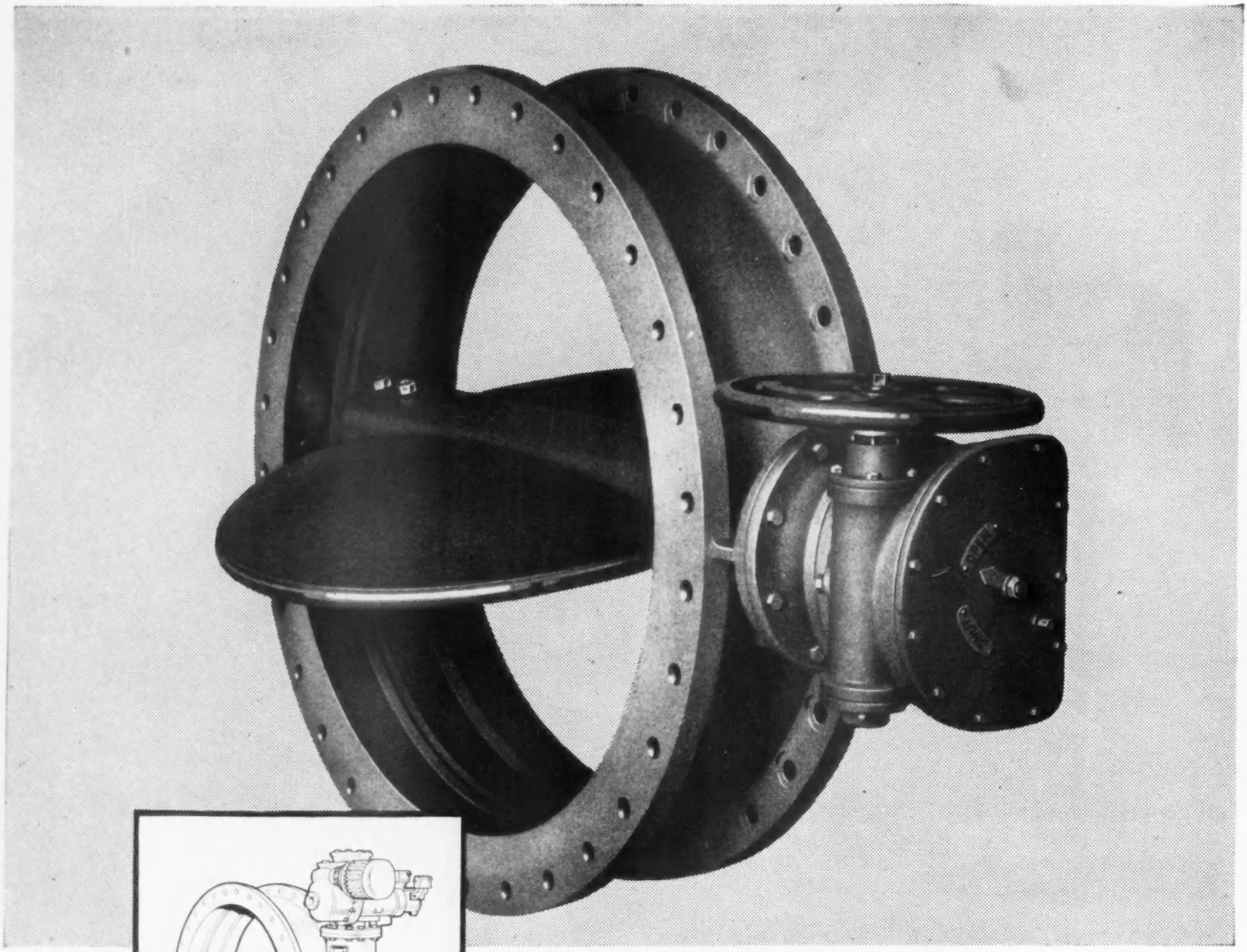

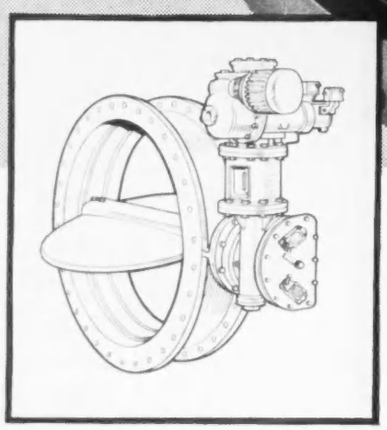

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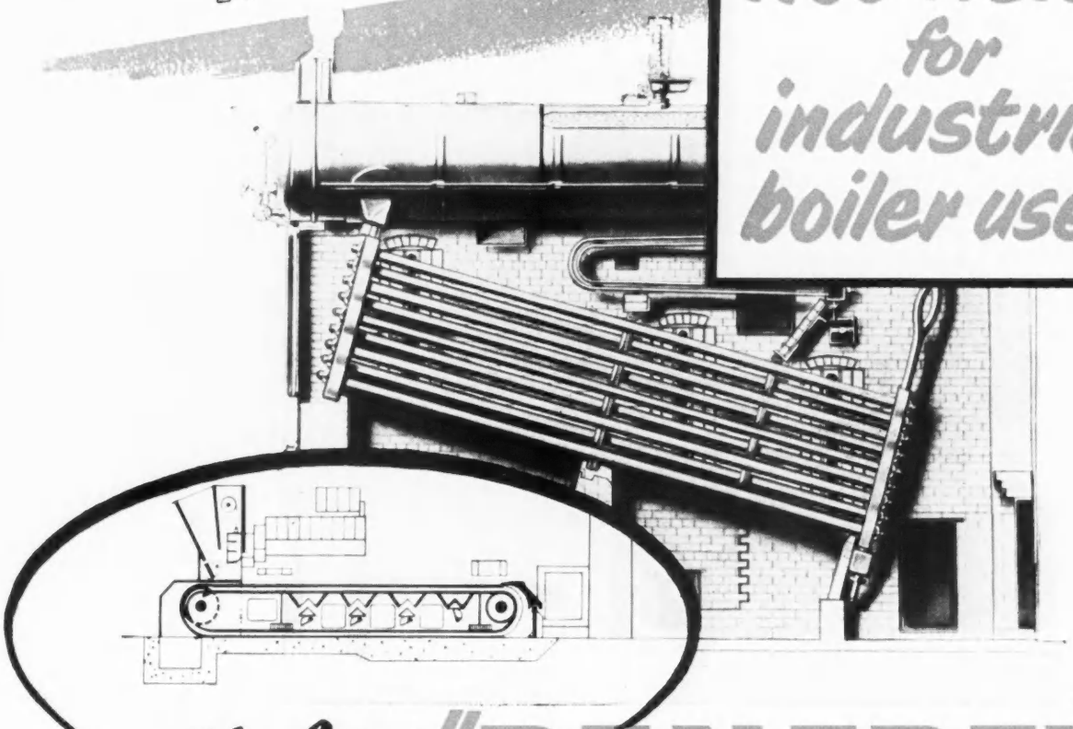

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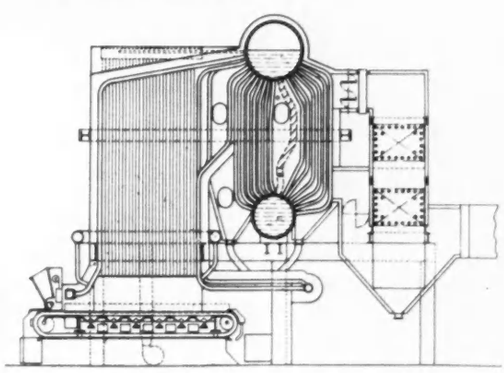

Sectional view of a Bi-drum boiler with **'Renfrew' stoker**

★ **CLEAN AIR ACT** *With its facility for application to existing boilers and its ability to provide* smokeless combustion *even with variable and low-grade fuels, the RENFREW stoker presents, at moderate cost, a highly effective means of meeting the requirements of the* Clean Air Act.

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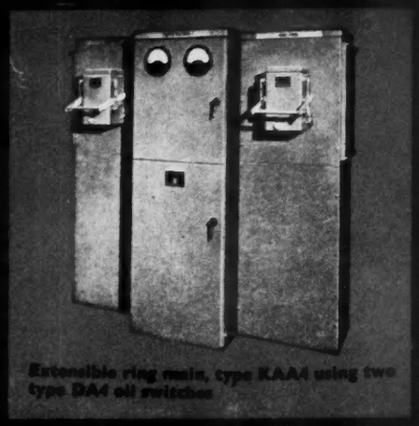
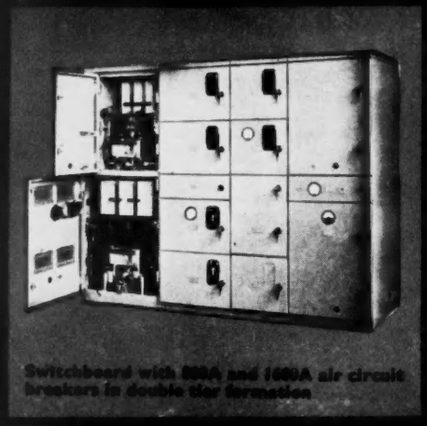


Extensible ring main, type KAA4 using two type DA4 oil switches



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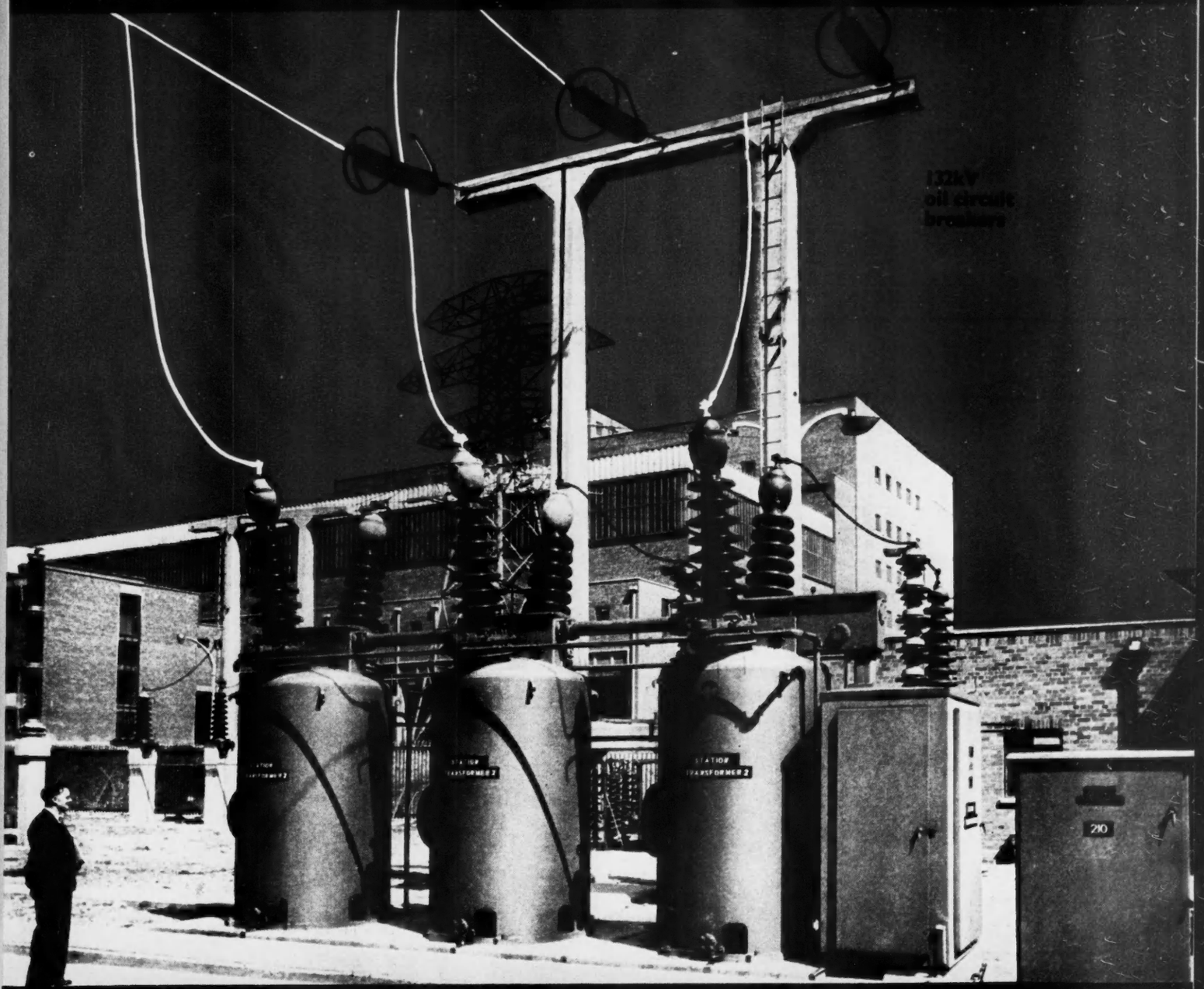
33kV, 750 MVA metalclad switchboard

66kV oil circuit breaker with pneumatic operating gear



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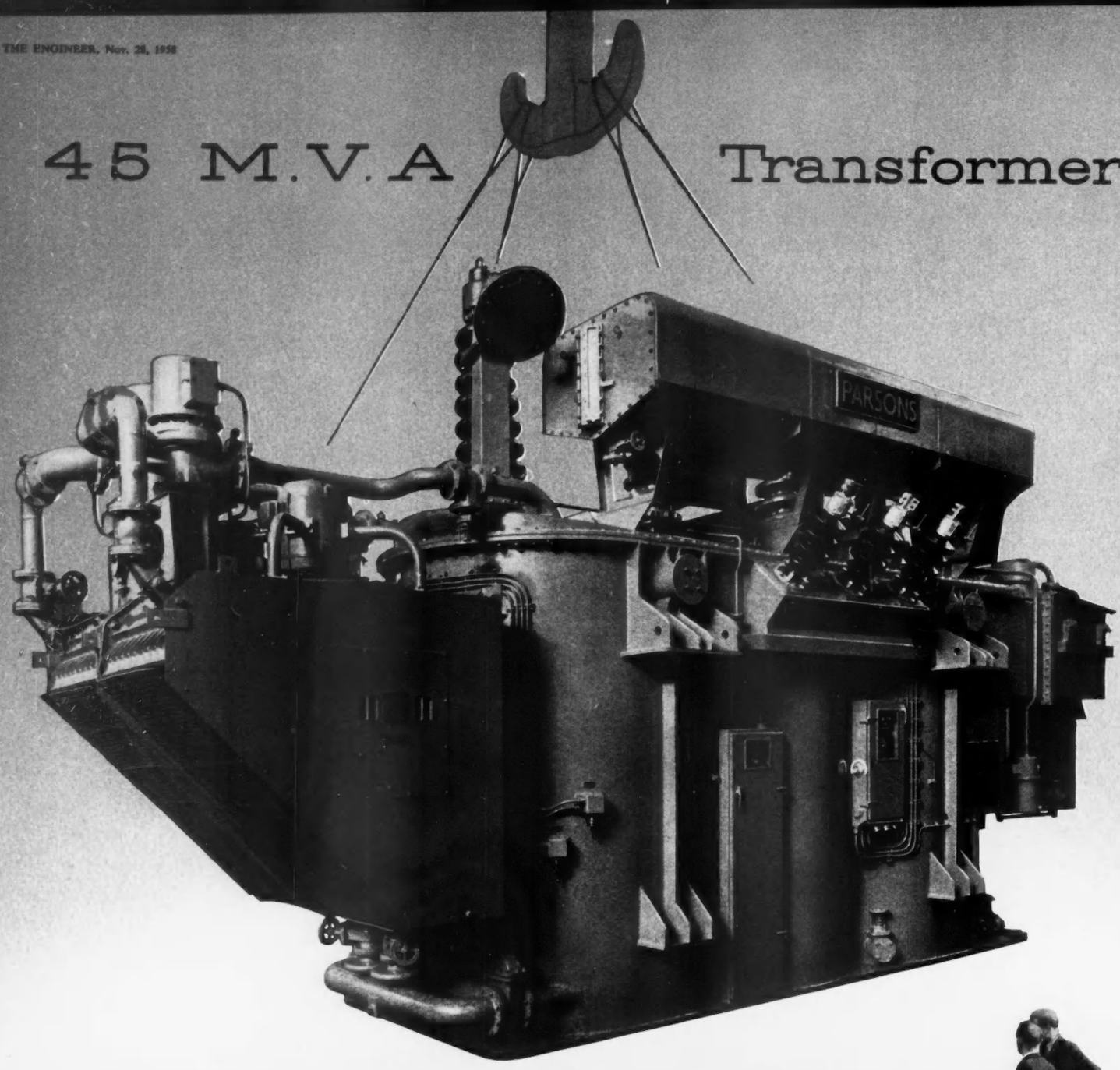

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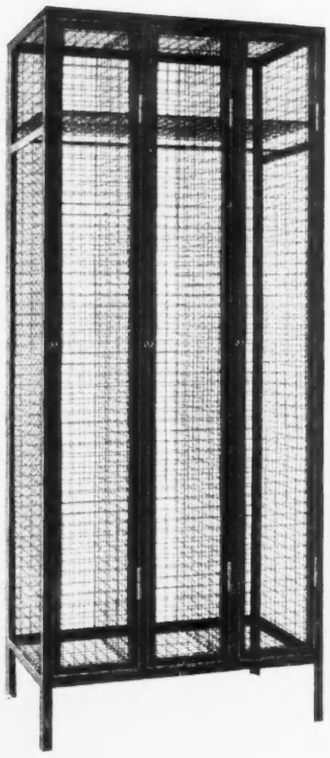
To meet a C.E.G.B. requirement for stand-by transformers which are readily transportable to required locations, Parsons have manufactured 45 MVA 3 phase 132 kV transformers, each transformer a compact single unit. They are big—as transformers of this capacity must be—but *not too big* to be lifted bodily and transported by road or rail to where they may be required.

PARSONS

C. A. PARSONS & COMPANY LIMITED · HEATON WORKS · NEWCASTLE UPON TYNE 6



An Important Amenity

Friction between employees, and confusion at going-home time may be avoided by providing separate receptacles for clothes and personal belongings. Such provision is also important in the interest of hygiene. 'Harco' Clothes Lockers provide the answer. They are made in sheet metal or wirework, in nests of up to five in one unit, with short or full length compartments as required. Steel lockers are fitted with six-lever locks which can differ up to 1600; wirework lockers have rings for padlocks. Height of both types is 72 ins.

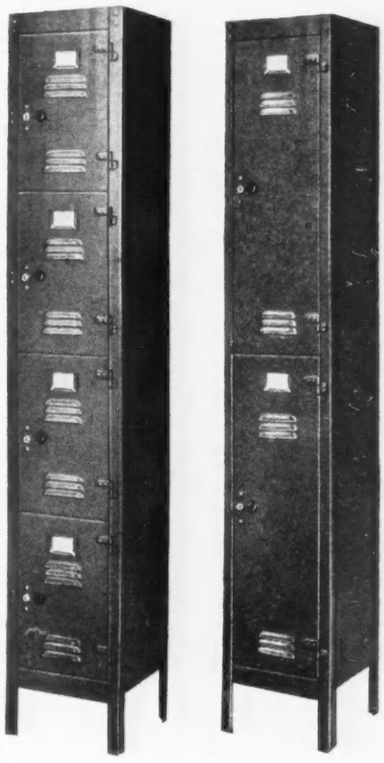
WIREWORK LOCKERS

Standard sizes:

72 in. high x 12 in. wide x 12 in. deep

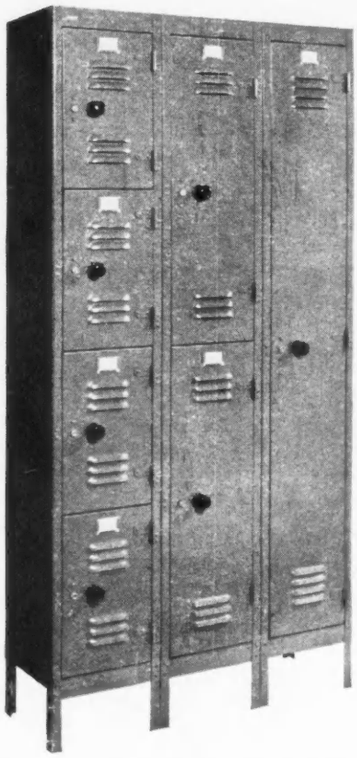
72 in. high x 10 in. wide x 18 in. deep

Please send for List No. E 1009



Wirework or Sheet Metal

in single units or nests of 2-5 as required



STEEL LOCKERS

Overall sizes:

72 in. high x 12 in. wide x 12 in. deep

72 in. high x 15 in. wide x 15 in. deep

72 in. high x 18 in. wide x 18 in. deep

1, 2 or 4 compartments per locker

Please send for List No. E 960

'Harco' Clothes Lockers

ARE HYGIENIC, DURABLE AND EASY TO INSTALL

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"Give your Ropes a chance"

give hints on how to make your ropes last longer. Your set is available on request. Useful data on the care of Wire Ropes have been collected and published by us and should be of assistance in obtaining maximum life.

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640 WOODBOROUGH ROAD, MAPPERLEY, NOTTINGHAM. Telephone: NOTTINGHAM 64397 and 66055/6
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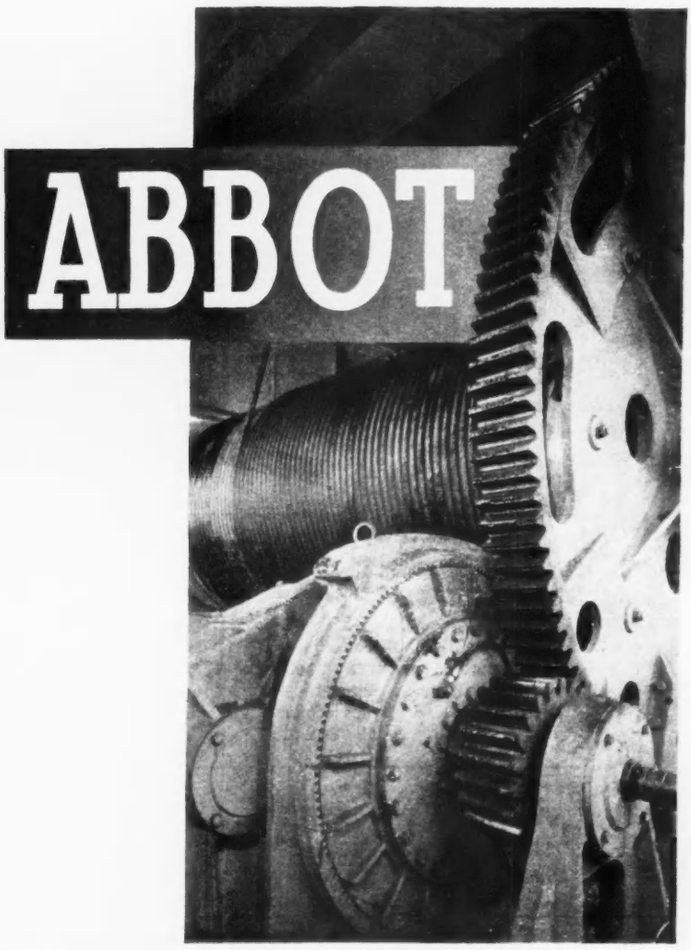
CARDIFF: D. M. STEVENSON & CO. LTD., THE EXCHANGE, MOUNT STUART SQ. Telephone: CARDIFF 32162

ALSO: MARTIN, BLACK WIRE ROPES (CANADA) LTD., 2082 ALBERT STREET, MONTREAL 3, AND 285 BERING AVENUE, TORONTO 18



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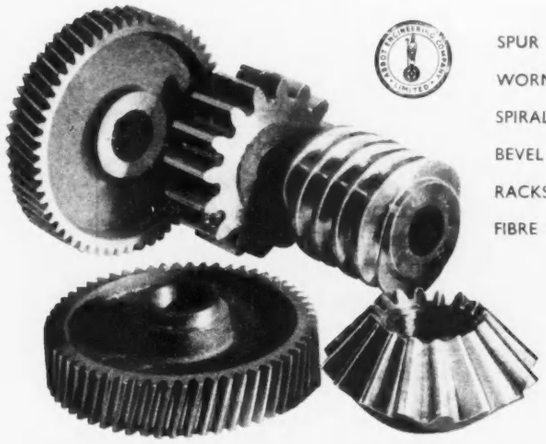
We guarantee the teeth of all wheels cut by us to be correct, and all work is examined and checked before being despatched. Each gear wheel of a pair is run in correct relative position to the other in a special gear-testing machine.

Our booklet "MACHINE CUT GEARS" contains much information of interest and use to engineers. A copy will be sent on request.



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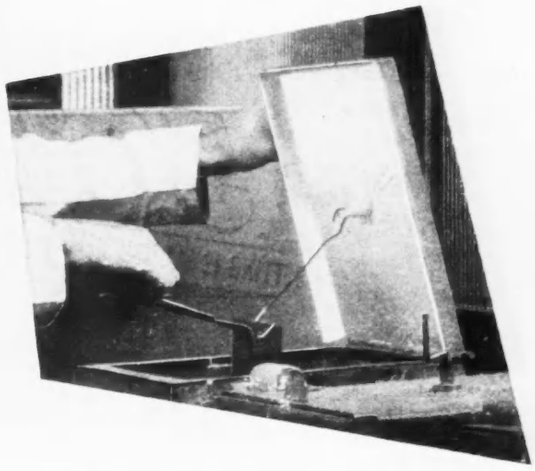

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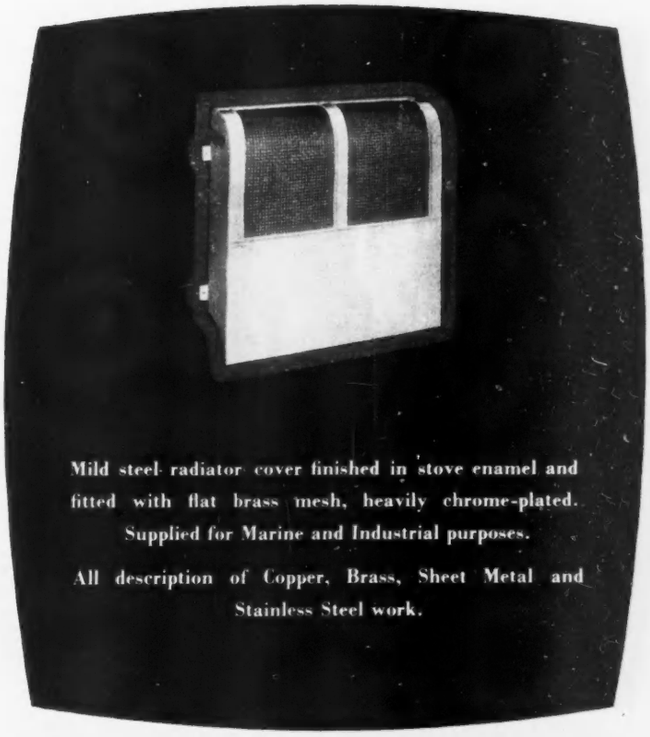

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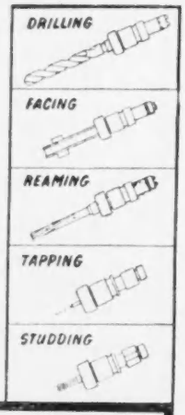

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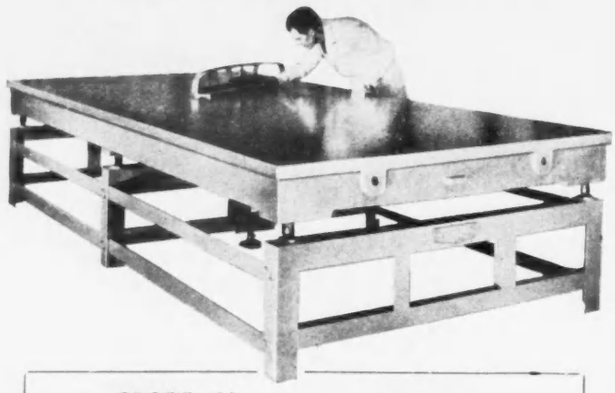

GRADE 'A'
Hand scraped and surfaced to within 0.0001 in.—0.0003 in. from a mean true plane over whole surface according to size.

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Smooth planed finish accurate to 0.001 in.—0.003 in. according to size.

Sizes up to 4'0"×2'0" have three-point support
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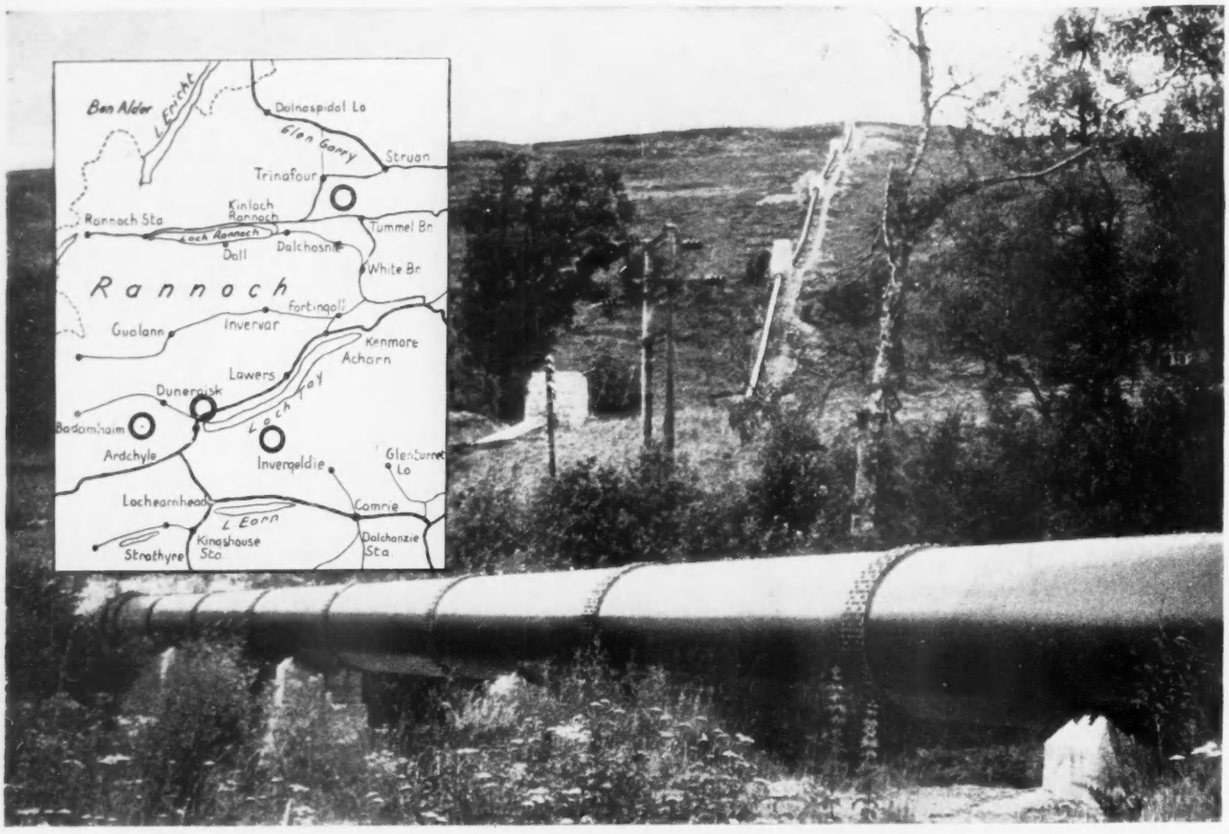

Tufnol pays the piper...

Up at Lawers in Perthshire, and other places where pipelines of the North of Scotland Hydro-Electric scheme run, engineers have exploited the advantages of Tufnol for bearing pads to support the pipelines. Many of the pads have already given several years of satisfactory service for, due to its inherent physical properties, Tufnol is the ideal bearing material for pipelines.

Firstly, Tufnol is a high grade electrical insulator and therefore helps to prevent corrosion inside the pipes caused by electrolytic action.

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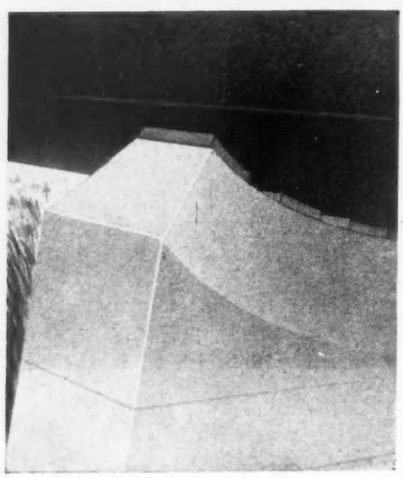
Thirdly, since Tufnol is sympathetic in contact with other materials, wear at the points of support is reduced to a minimum when the pipes expand or contract. Further, because of Tufnol's hardwearing qualities the pads themselves are little affected by this movement of the pipes.



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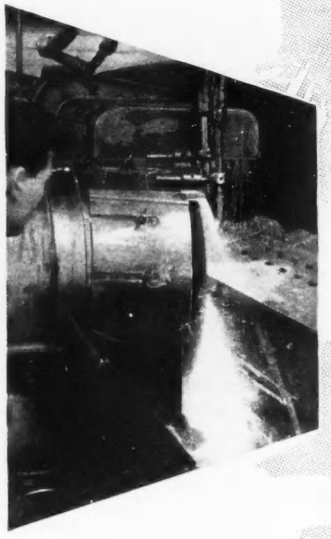

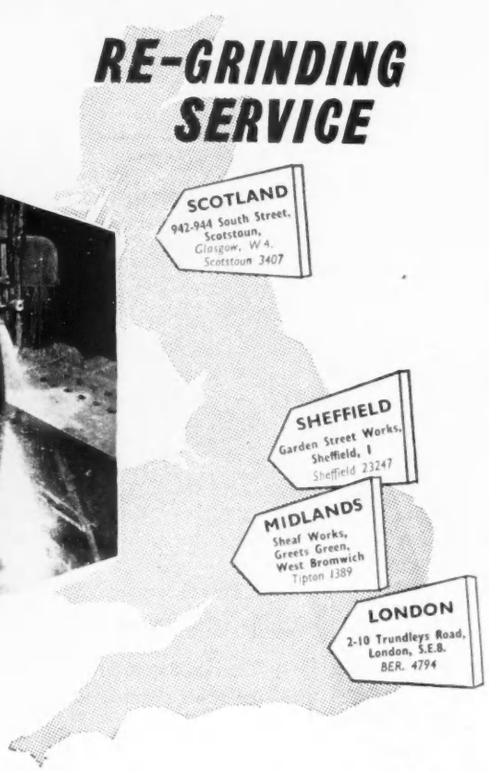
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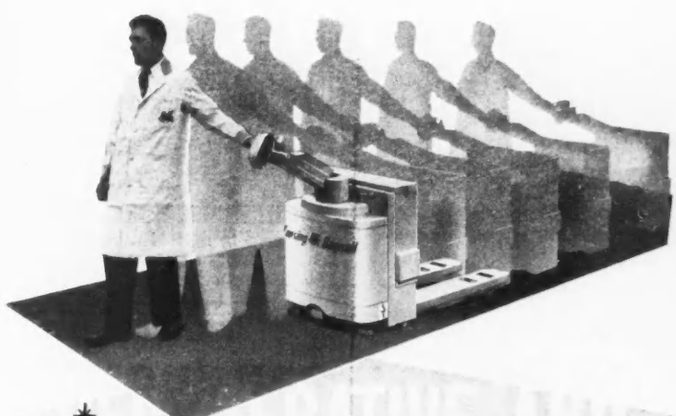

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Mechanical braking wastefully dissipates costly energy, quickly wears brake linings and is costly to maintain at optimum efficiency even under perfect conditions. Its use, and its control over safety, are completely subject to human frailty.

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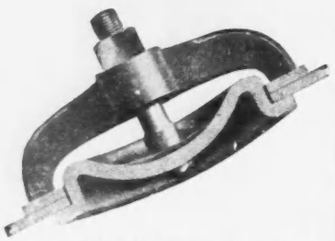

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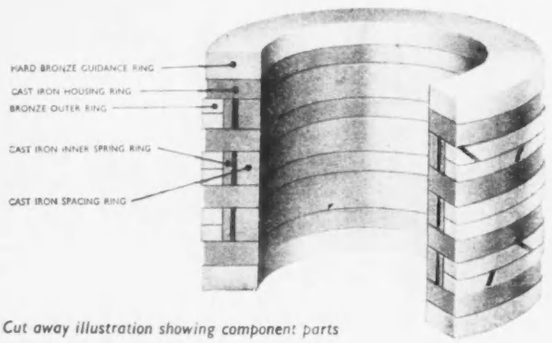
BUILT-UP PISTON ASSEMBLY

For HYDRAULIC WORK AND HIGH PRESSURE SEALING



Cut away illustration showing component parts

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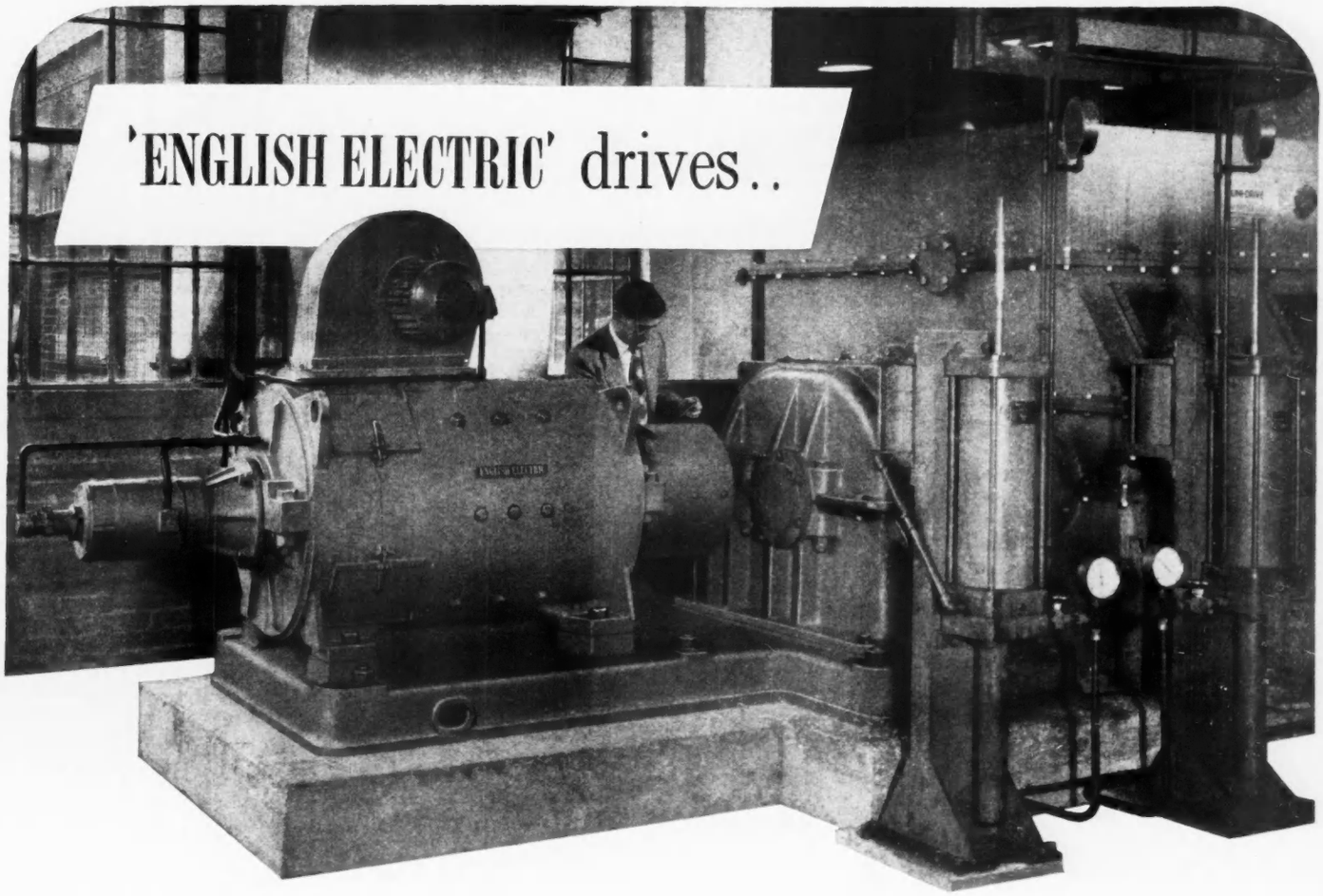
★ Make overloading impossible
★ Do not depend on the vision, care or skill of the operator for their accuracy
★ Are unaffected by side loads
★ Give precision results with unskilled labour
★ Retain their accuracy for long periods of continuous use without attention

Sixteen models provide for loads up to 850 lbs/ft
Also Hydraulic Torque Generators for loads up to 3,000 lbs/ft



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Rapid emergency stopping of the calender train is achieved by two-stage electrical braking, both dynamic and regenerative. The fully automatic magnetic amplifier and contactor control scheme permits fabric changing without shut-down and ensures accurate speed matching between the two 300 h.p. calender motors. It also provides, in conjunction with seven 'ENGLISH ELECTRIC' auxiliary motors, accurate tension control and correct sequence of operations between auxiliary sections.

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drives for the rubber industry

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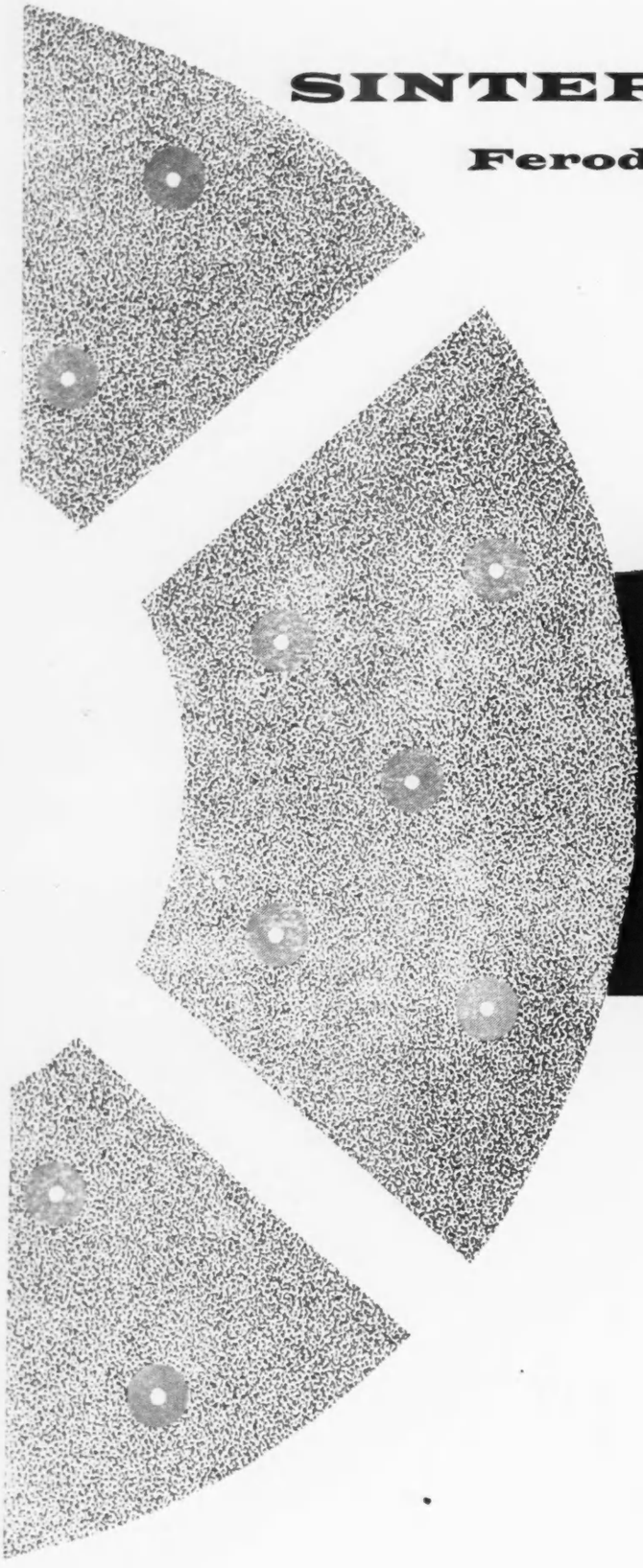

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High Thermal Conductivity gives

* LONG LIFE
* MINIMUM DISTORTION
* COOLER RUNNING
* MINIMUM HEAT CHECKING

Ferodo Sintered Metals withstand

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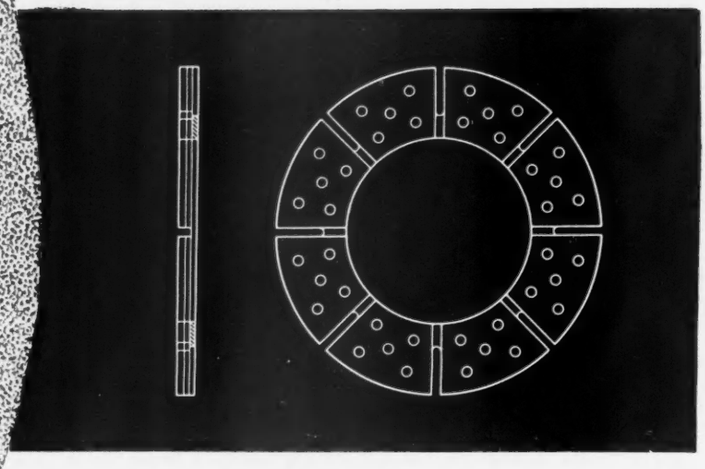
Reduced ratio of static to dynamic friction coefficients leads to

* SMOOTHER ENGAGEMENT



Ferodo Sintered Metal Types

SM.1 General purpose material for dry and oil immersed applications

SM.2 For oil immersed applications requiring smooth, gradual engagement such as automotive automatic transmissions

SM.3 Specially suited to dry, heavy duty applications such as engine master clutches on trucks and on tractor steering clutches

SM.4 Is intended as a mating surface for use against other Ferodo sintered metals to protect costly parts from heat damage and wear

SM.5 For oil immersed applications involving long slip periods such as seals and tension controlled clutches

SM.6 For oil immersed applications where smooth engagement must be coupled with relatively high rating

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Sintered Metal Clutch Facings

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BOLTS, NUTS, SPECIAL FASTENINGS

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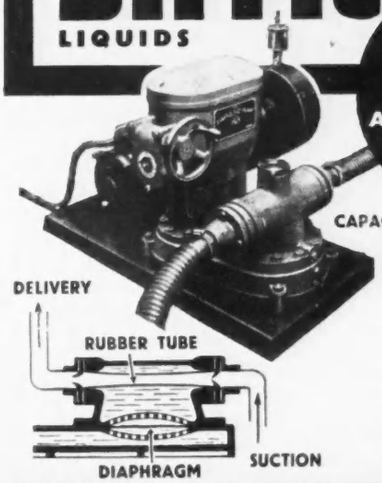

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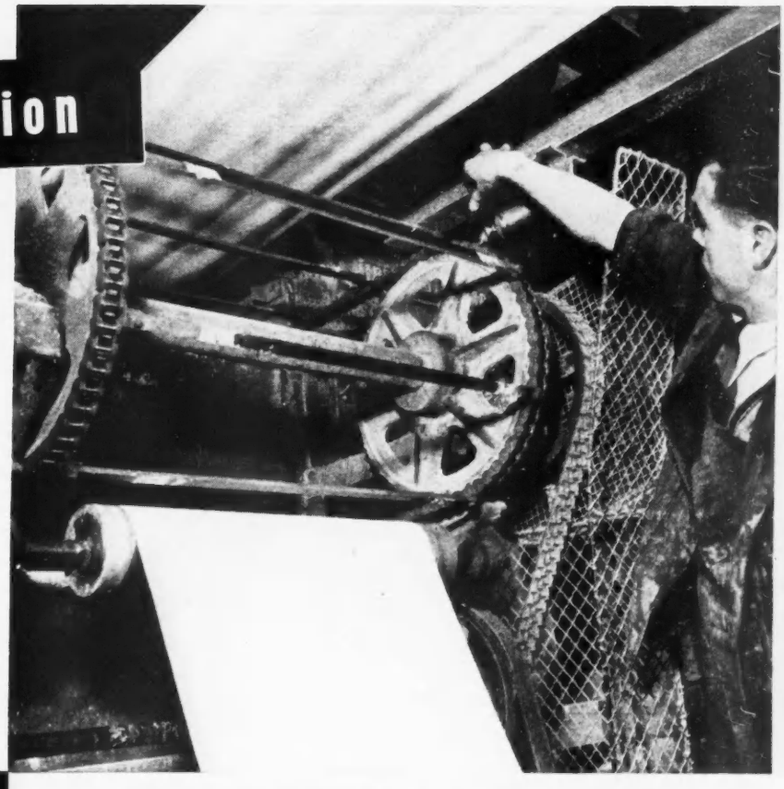
WITH 'dag' COLLOIDAL GRAPHITE



When wallpapers are printed, cleanliness is all-important. Oils and greases that splash, drip, or run, are out of the question. At the works of The Wallpaper Manufacturers Ltd., Leeds (a member of the Crown Group) conventional oils and greases cannot be used on the fast-moving conveyor chains of the drying unit, which operates at a temperature of 220° Centigrade. After testing all possible lubricants, Crown adopted an Acheson dry-film lubricant, 'dag'* Dispersion 2404 (colloidal graphite in white spirit), and this product has been standard at the Leeds works for many years. For effective, economical and long-lasting lubrication of conveyors, chains, and other equipment working to "no-soilage" rule, Acheson dry-film technique is the answer. If you feel that 'dag' dispersions could help to solve problems for you, we shall be pleased to send a Field Engineer to carry out a lubricant survey without obligation on your part.

Conveyors and chains are dealt with in our Information Sheets P1 and P2. We shall be pleased to send copies.

**Registered Trade Mark of Acheson Industries (Europe) Ltd., licensed user Acheson Colloids Ltd.*

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Also Acheson Colloids Company, Port Huron, Michigan U.S.A., and Acheson Colloiden N.V. Scheemda, (Gr.) Netherlands.

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Regd. Trade Marks: PUROLATOR, 'MICRONIC'

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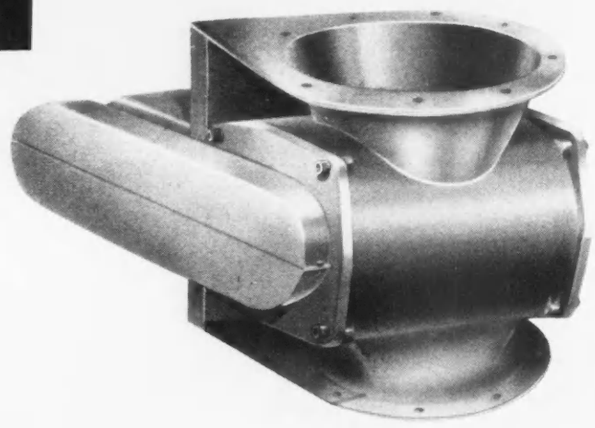
THE LATEST MODEL MIKRO-D AIRLOCK HAS THESE NEW FEATURES : Straight side inlet throat ; removable outboard bearings ; packing glands on both ends of shaft ; new drive arrangement which allows the airlock to be dismantled in situ. These developments are the result of continuous liaison with users in many industries.



Essentially the Airlock consists of a cylindrical housing in which a vaned rotor turns slowly and conveys material from an upper chamber to a lower by gravity. The vanes being rigid or tipped with rubber or plastic provide an effective seal by close contact with the cylinder.

The Mikro-D Rotary Airlock provides an ideal method of feeding material under pressure or vacuum while preventing the passage of air or gas. For use with silos, pneumatic conveying systems, dust collector equipment, pulverizers, etc.

It can also be used as a feeder to regulate the flow of material from a storage bin or hopper, or from the discharge of a blender or mixer.

STANDARD UNIT DATA

Size	Cap. range cu. ft./hour @ std. speed	Price
5"	50	£85
8"	250	£90
12"	850	£125
18"	2900	£200
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These prices are for Airlocks in mild steel or cast iron ; a similar range is available with all contact surfaces in stainless steel or other metals most suitable to individual needs. Airlocks can also be supplied for intermediate capacity.

MIKRO-D PRODUCTS include : PULVERIZERS, DUST COLLECTORS, AIR CONVEYORS, Airlocks, Crushers, Feed Controls.

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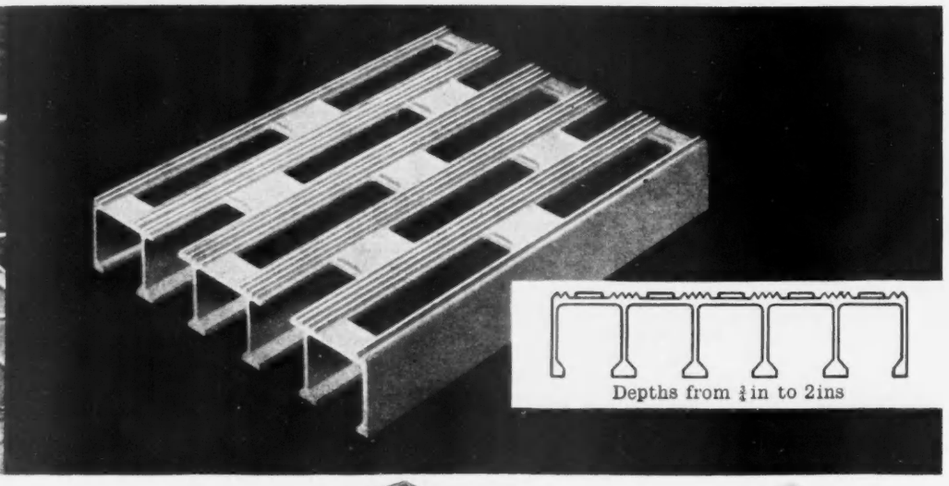
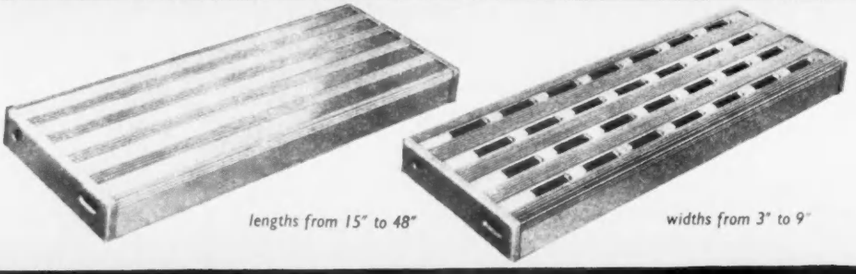
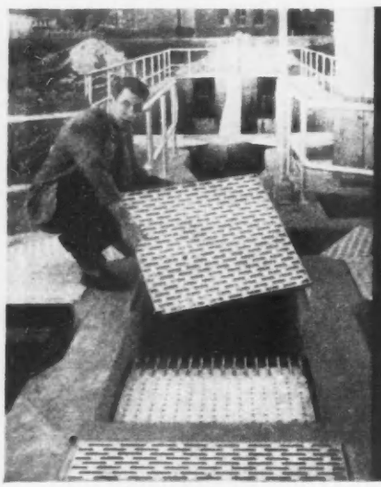
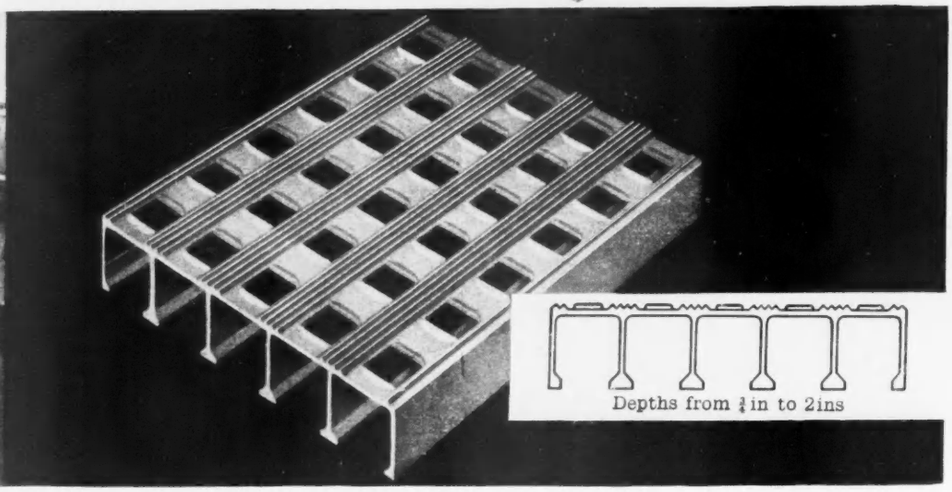


'ALAFLOR' Treads Plain or Punched







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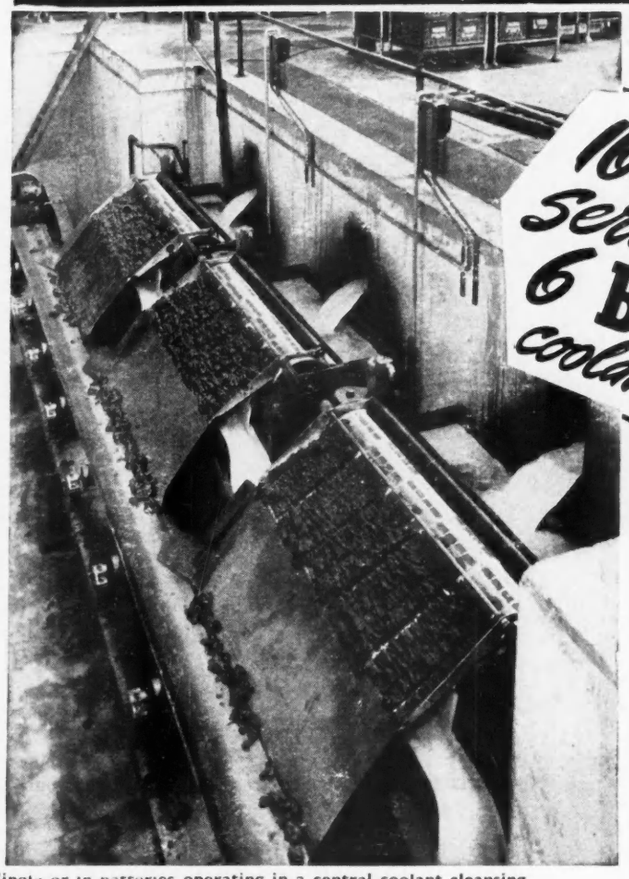

Patent Nos. 603083 731655, 745604 others applied for.
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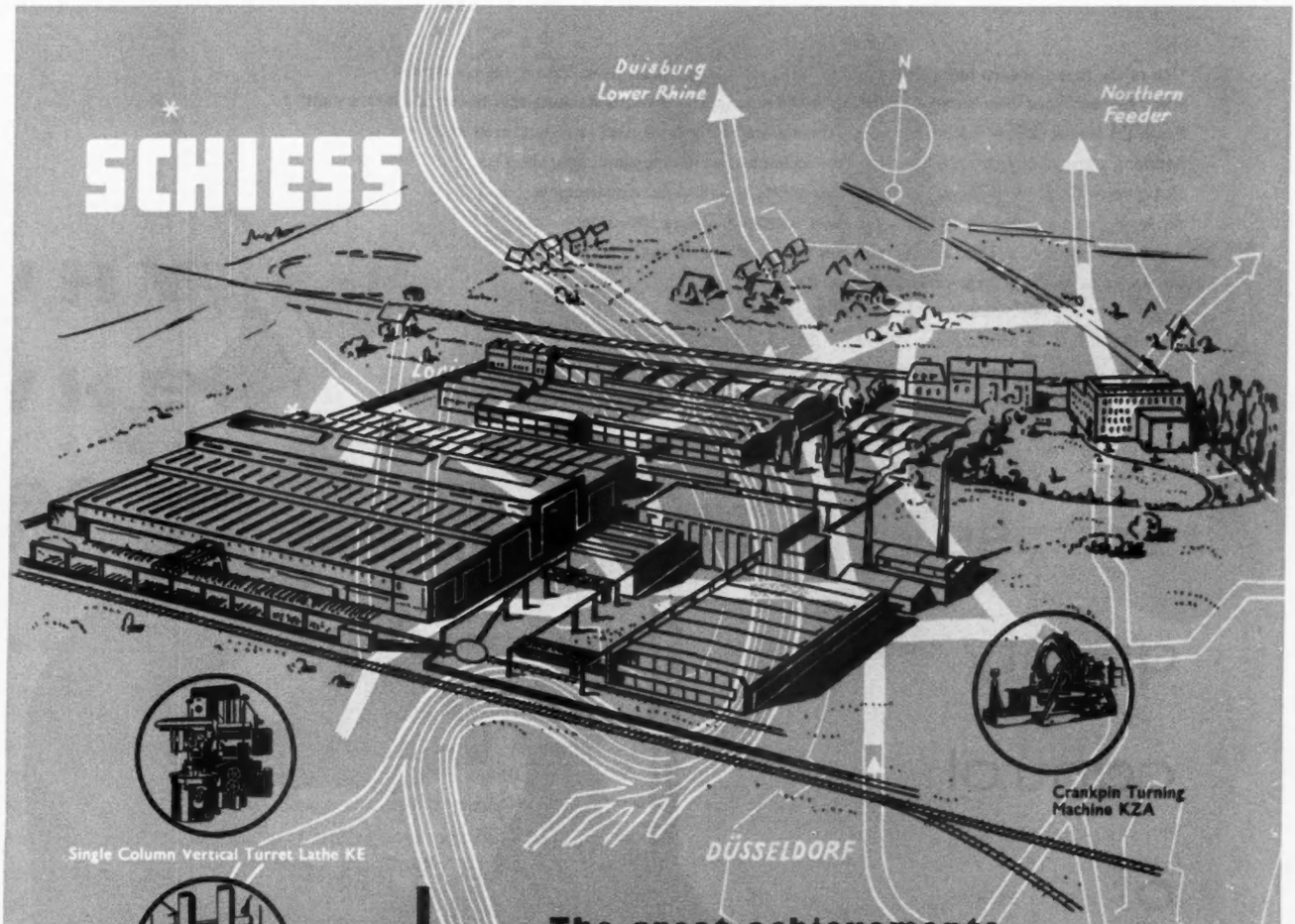
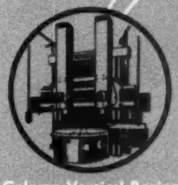
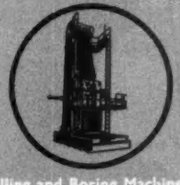


Single Column Vertical Turret Lathe KE



Double Column Vertical Boring Mill KZ

Vertical Boring Mill K



Milling and Boring Machine FB

Gear Hobbing Machine RF

Crankpin Turning Machine KZA

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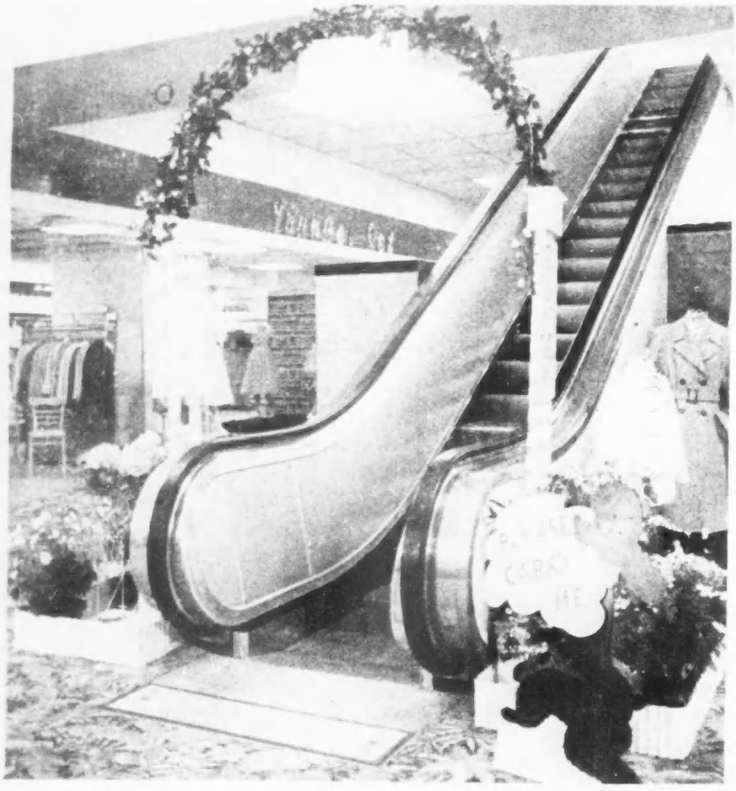

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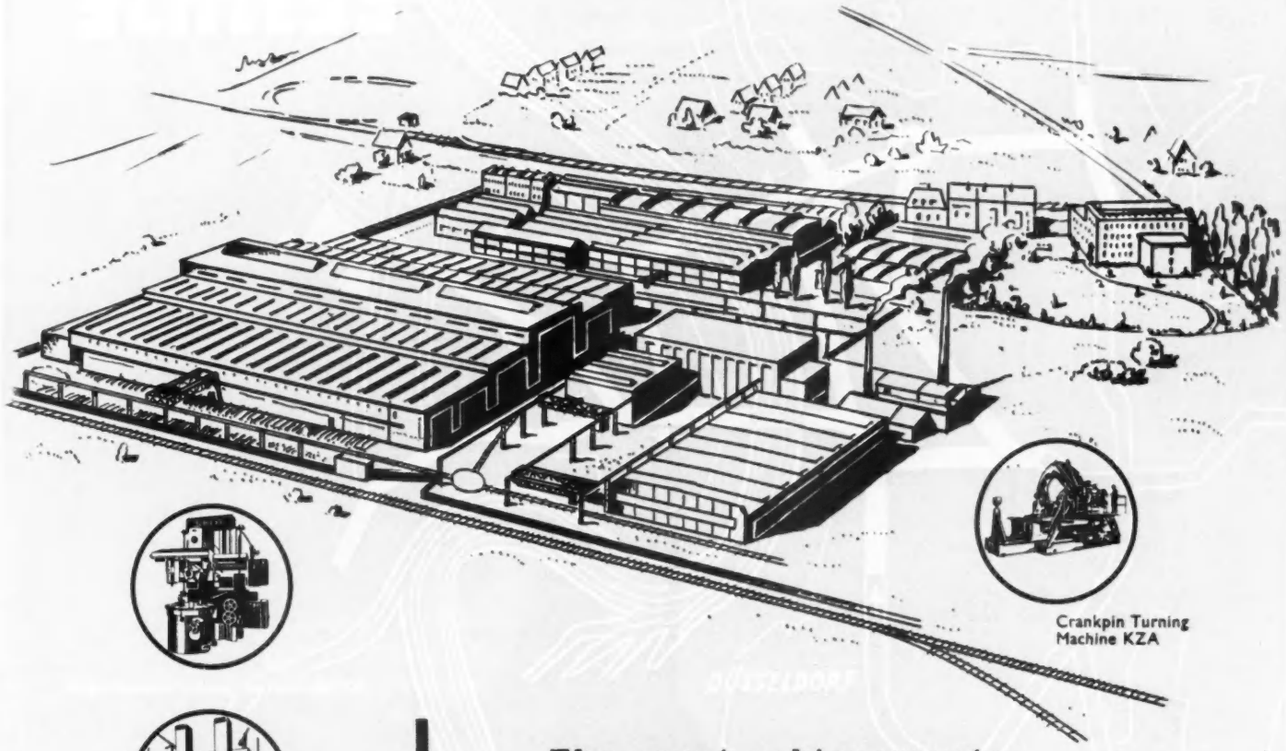
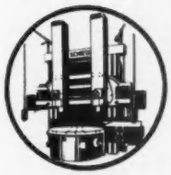
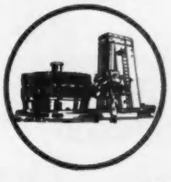


Crankpin Turning Machine KZA





The great achievements in technical progress

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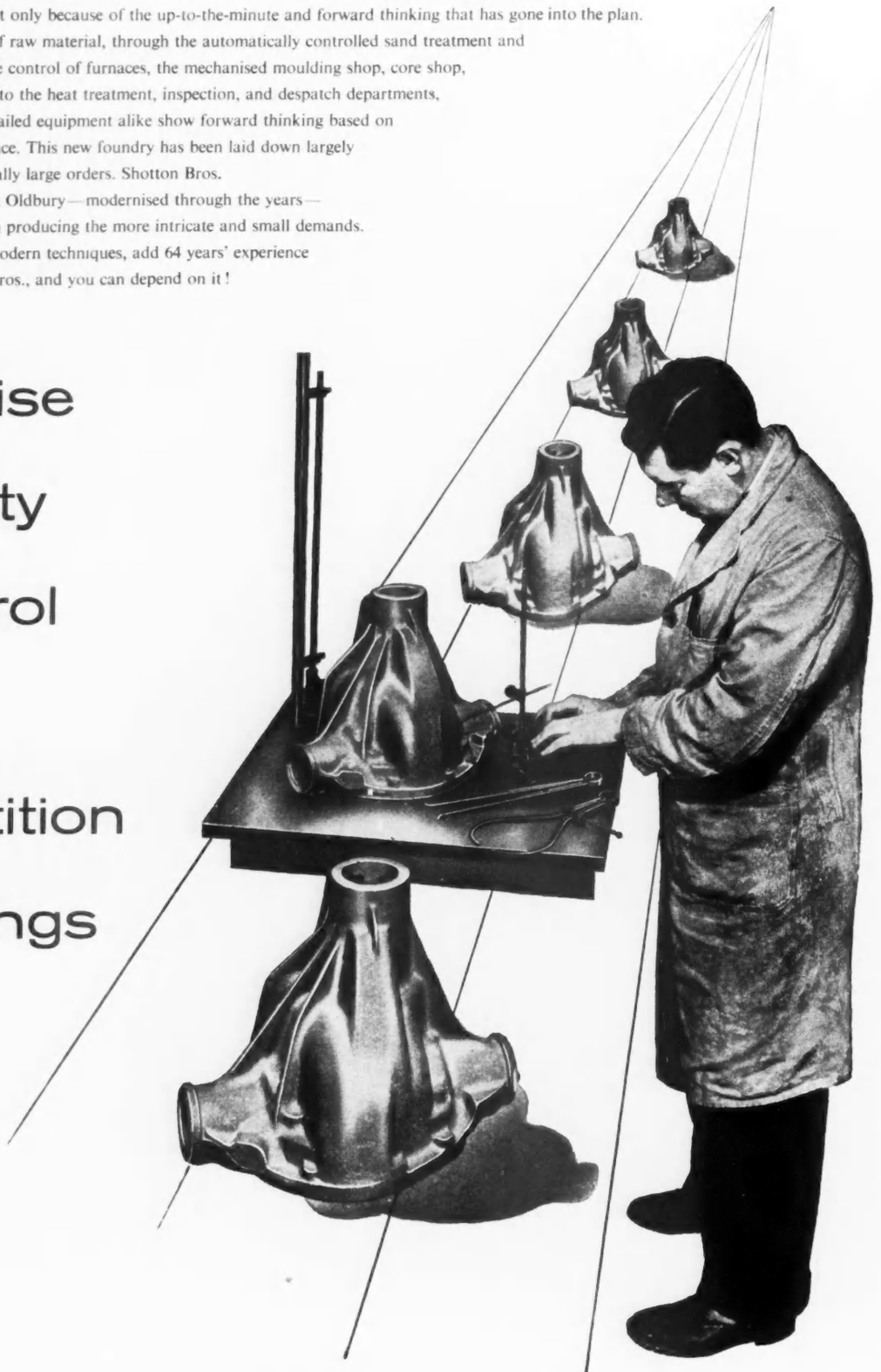

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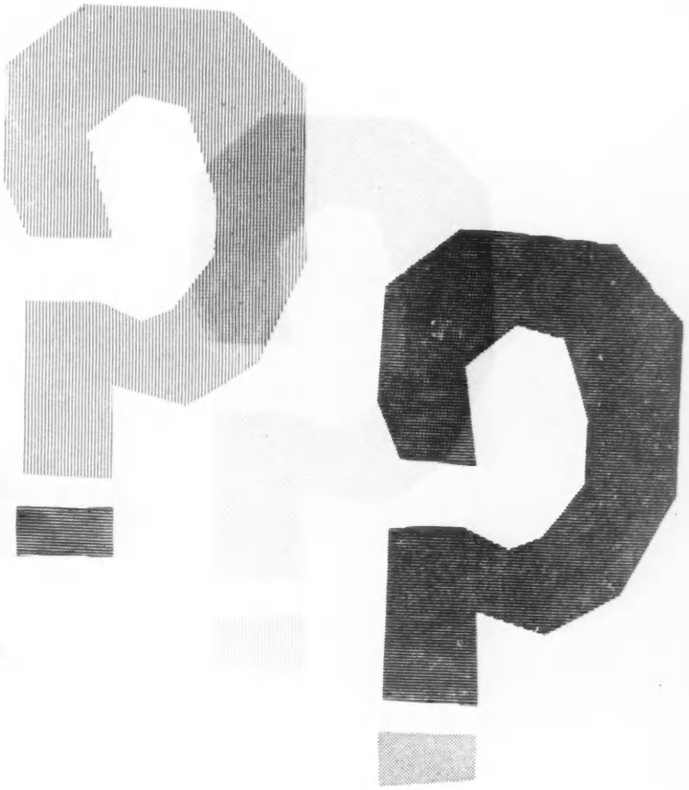

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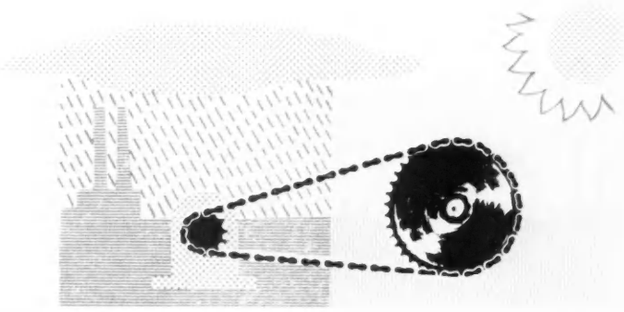

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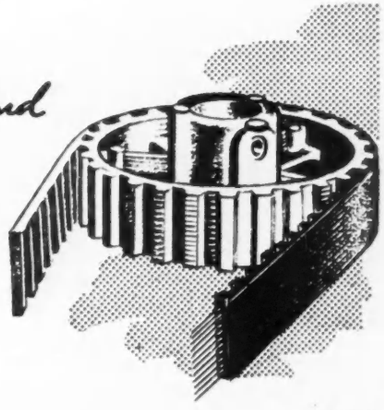

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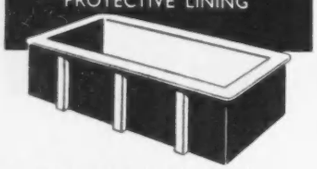

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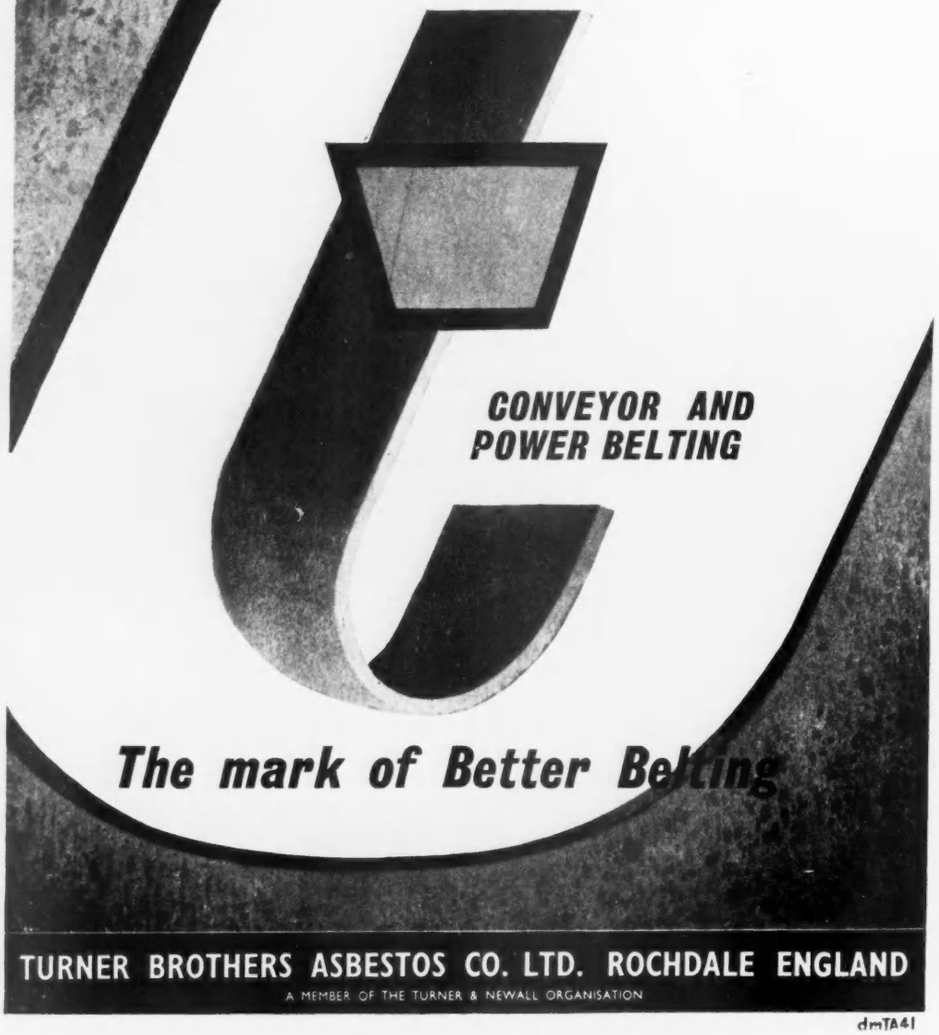

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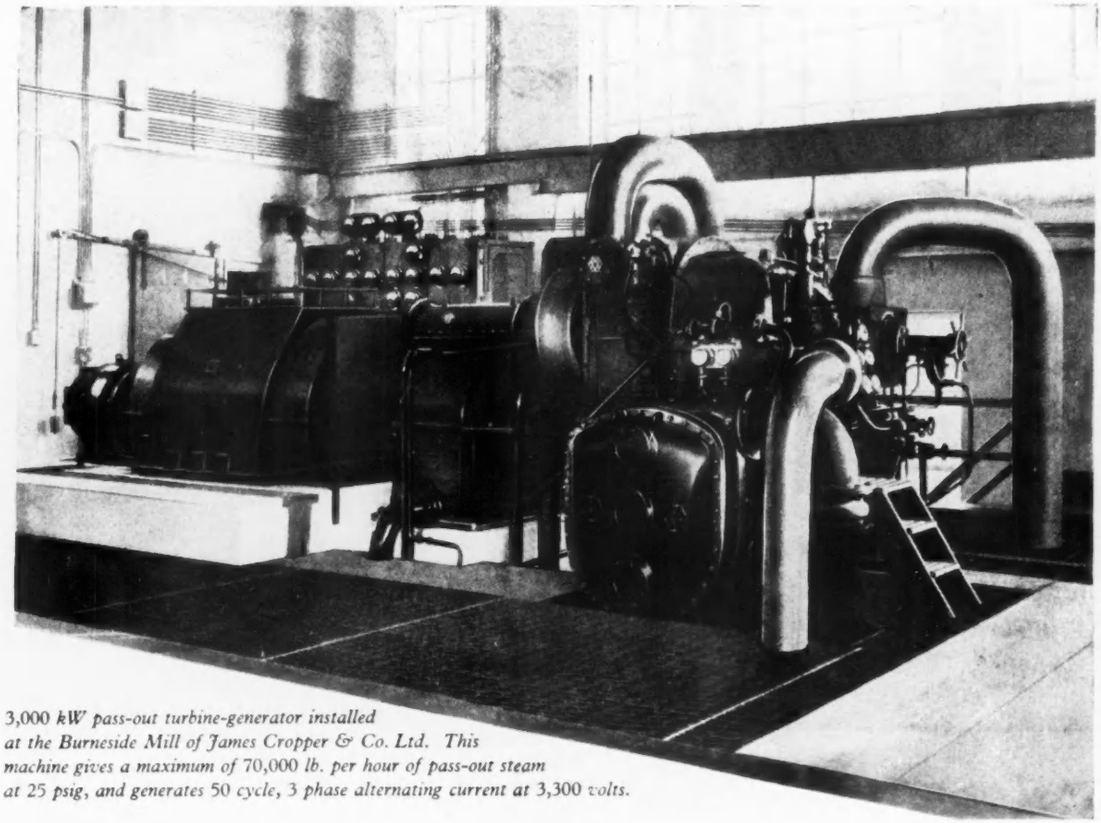

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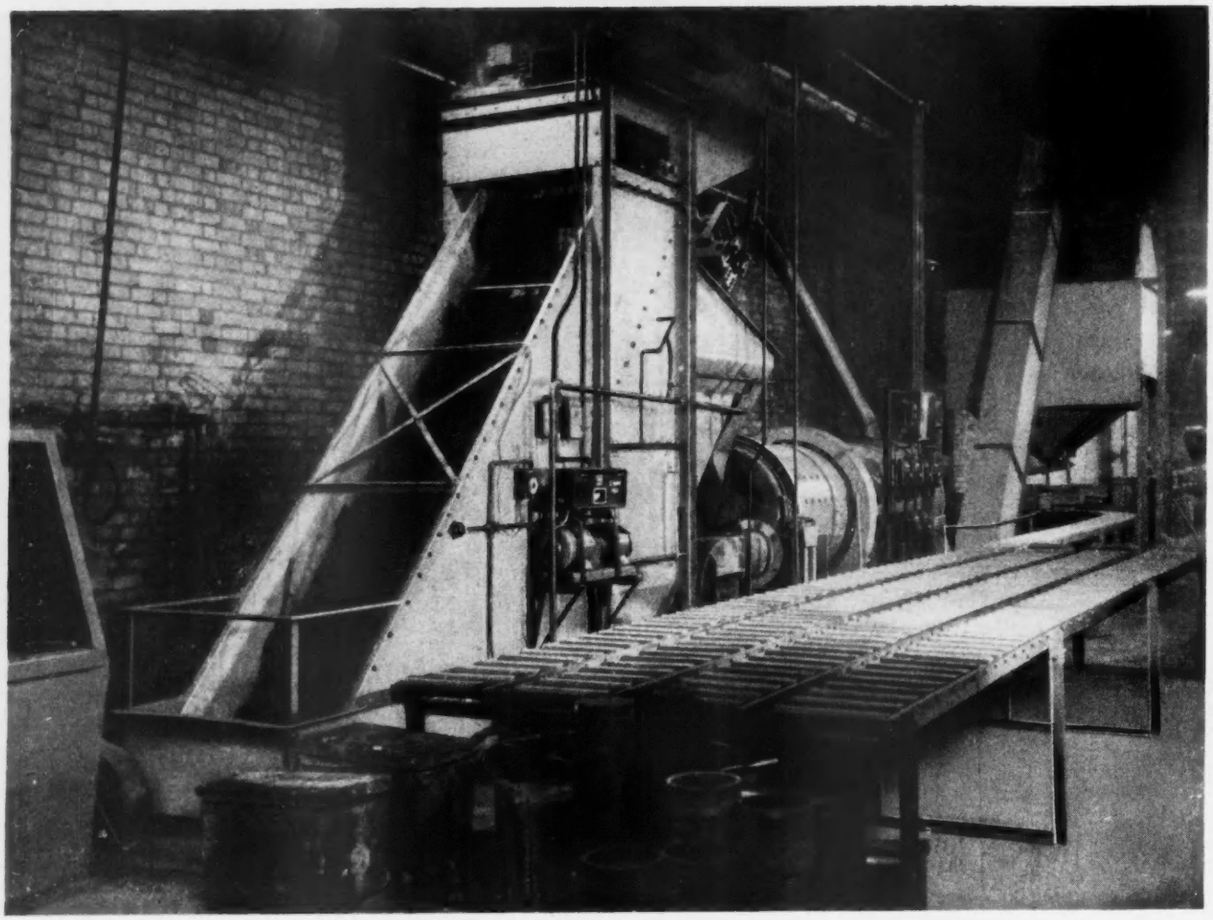

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- **CRANES & LIFTING APPLIANCES**
- **ELEVATORS**
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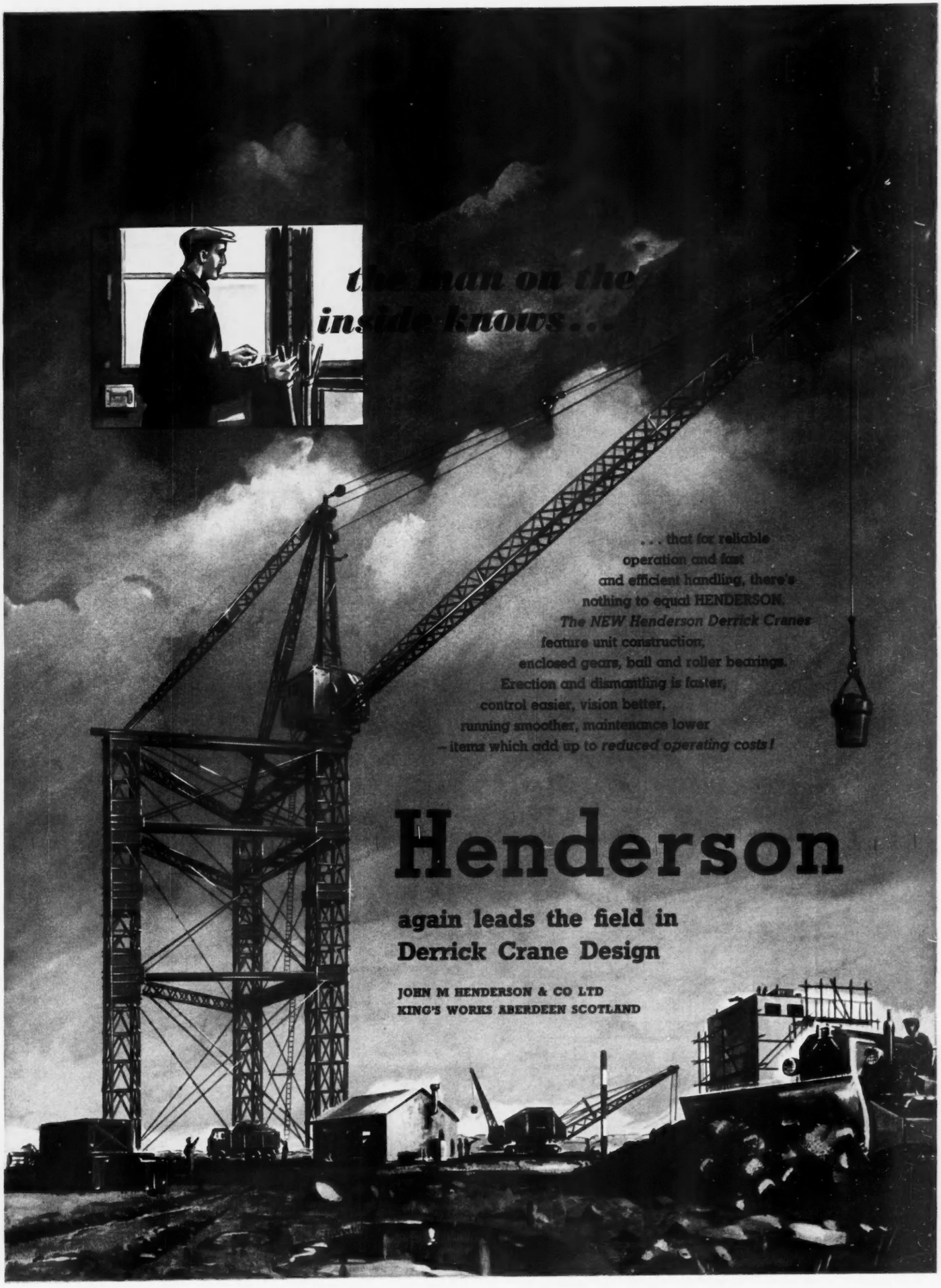
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. . . that for reliable
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Erection and dismantling is faster,
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– items which add up to reduced operating costs!
Henderson
again leads the field in
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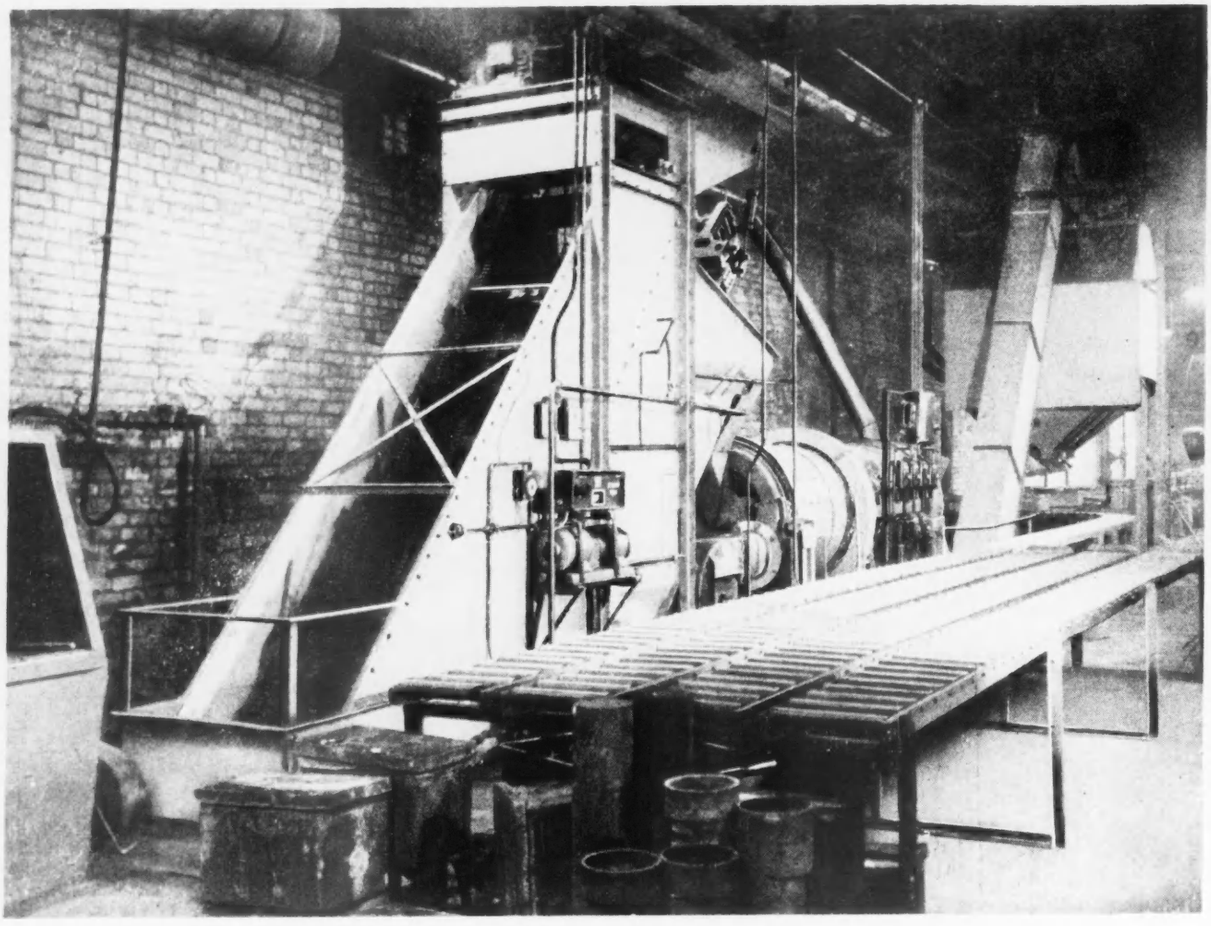

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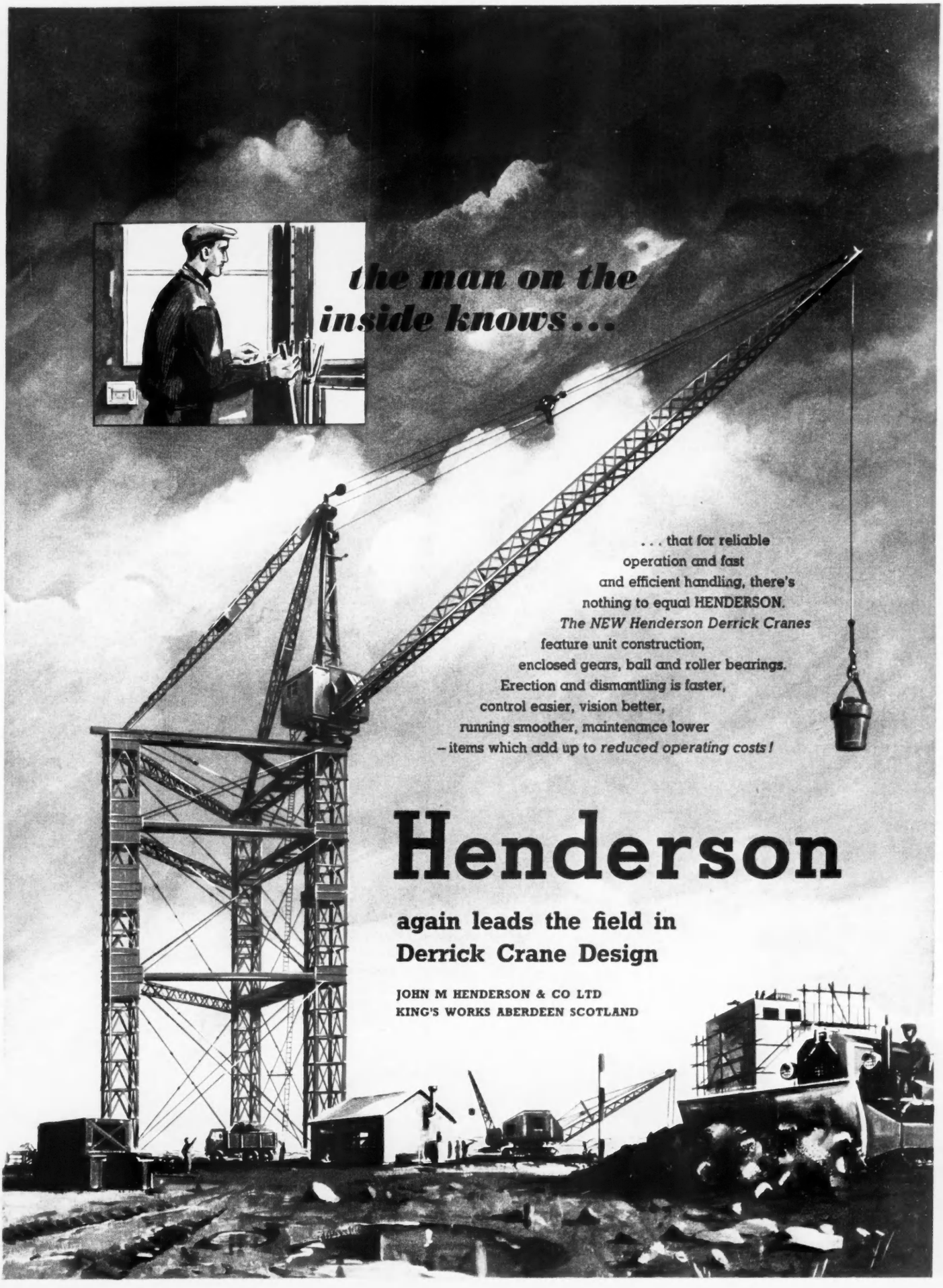
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. . . that for reliable operation and fast and efficient handling, there's nothing to equal HENDERSON.
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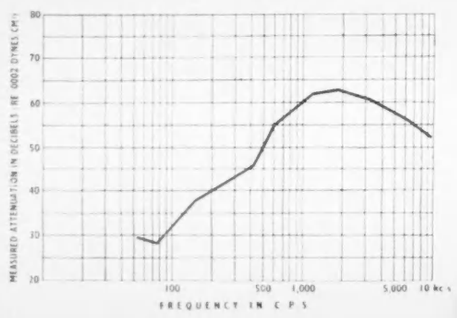

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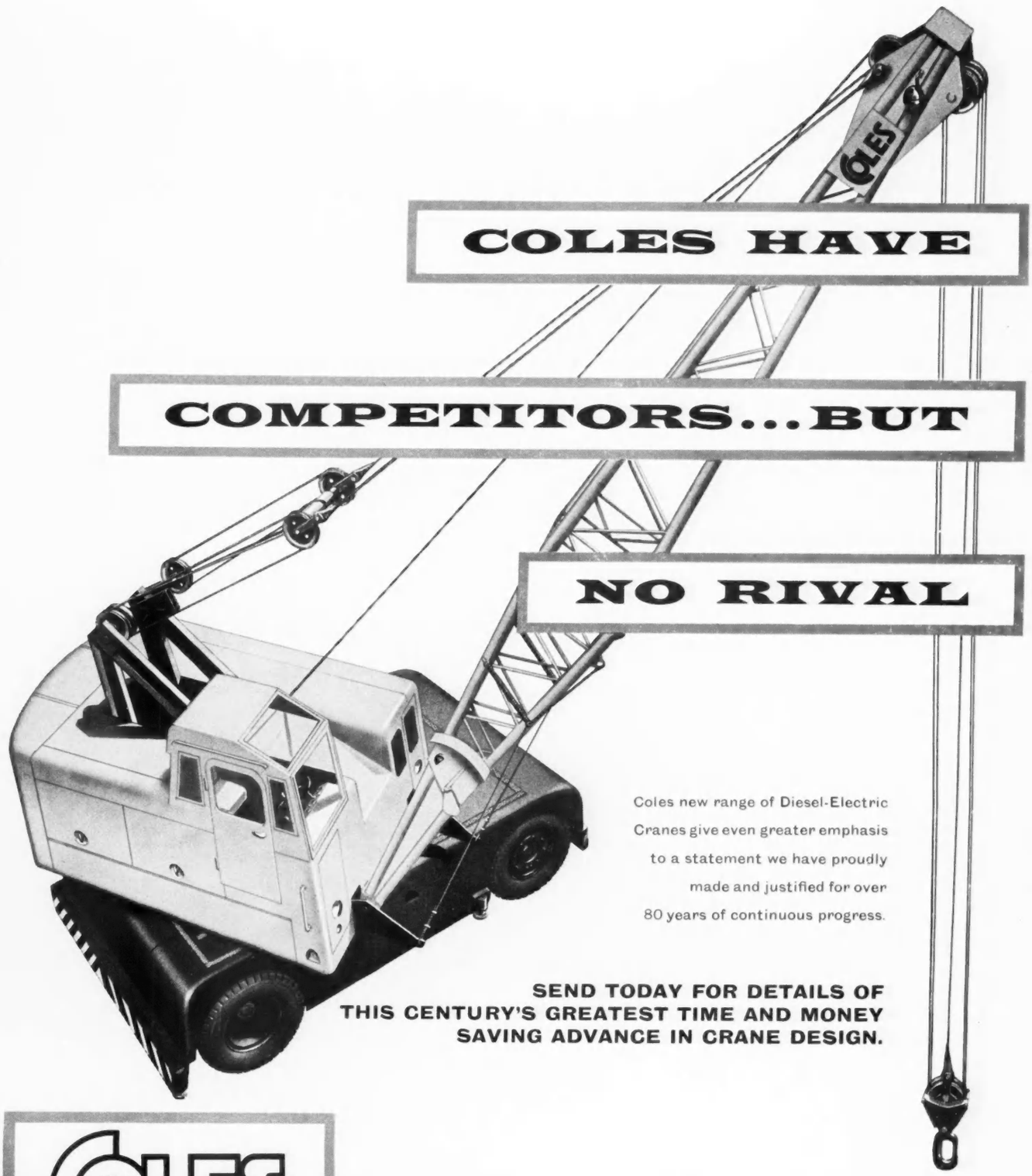

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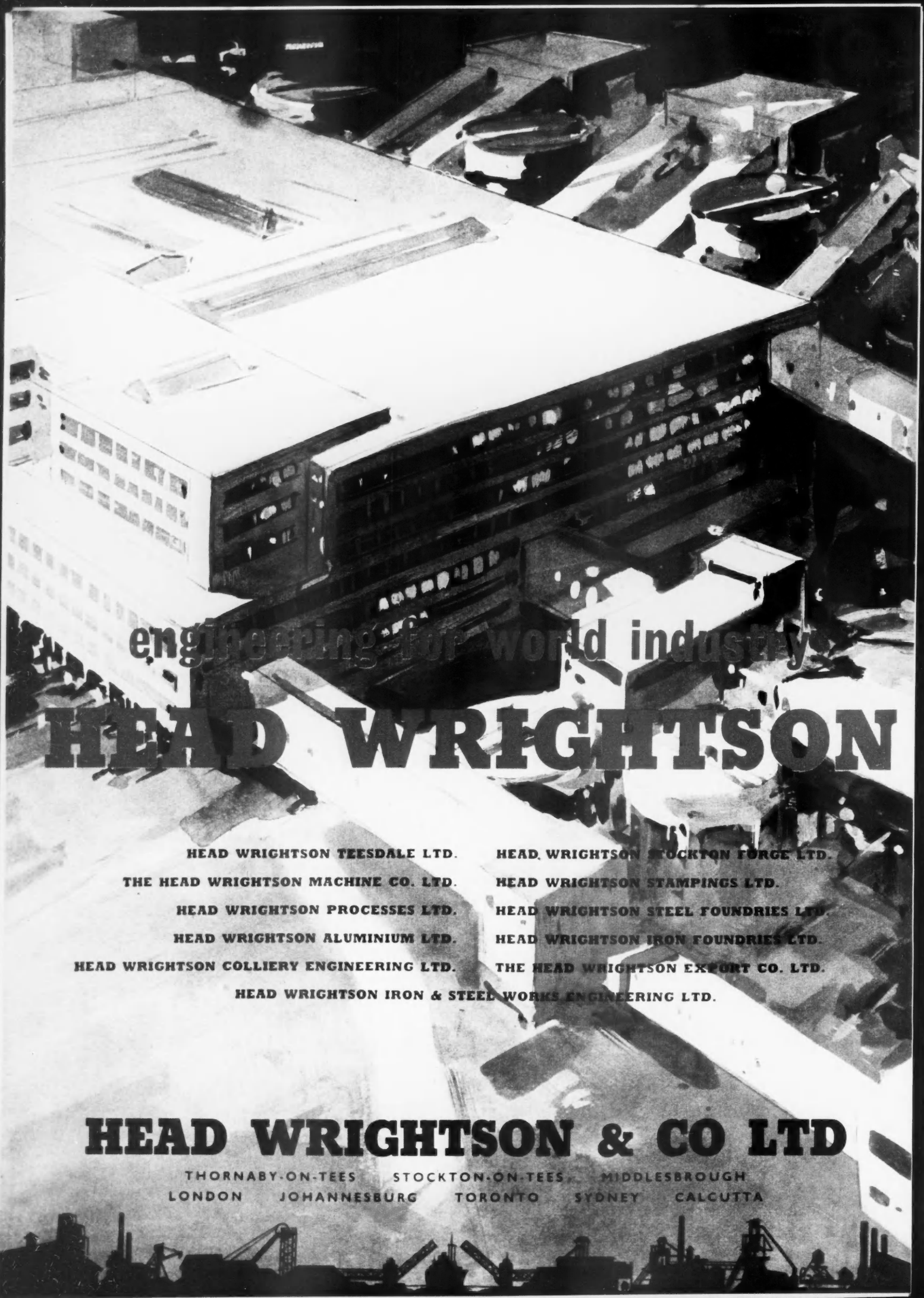

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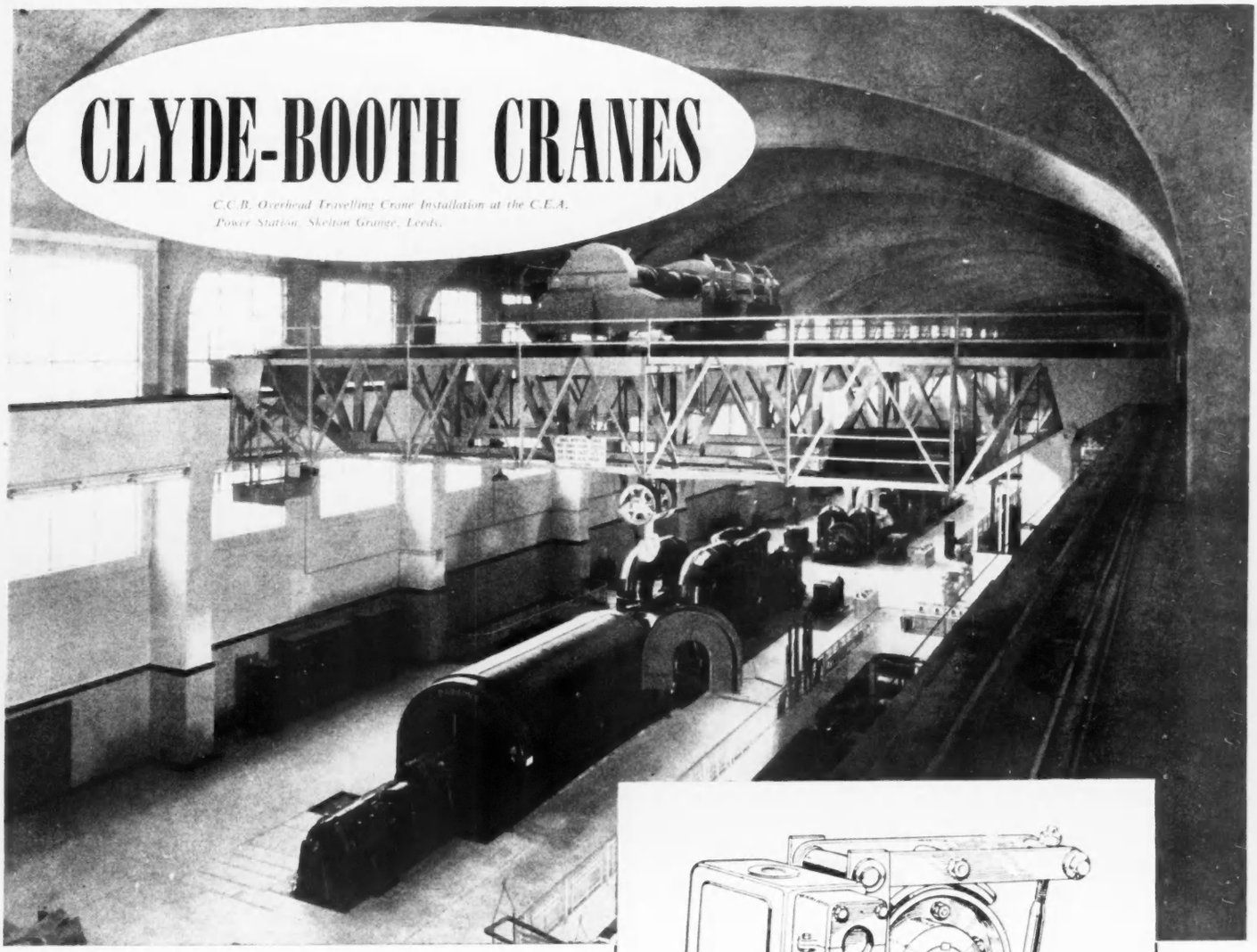
C.C.B. Overhead Travelling Crane Installation at the C.E.A. Power Station, Skelton Grange, Leeds.



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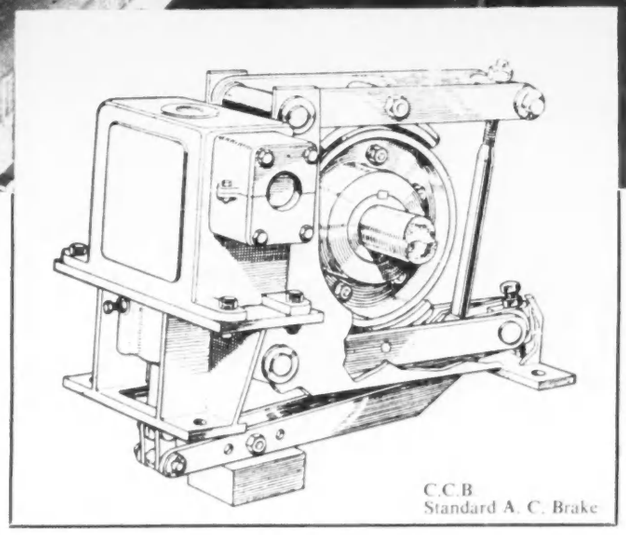

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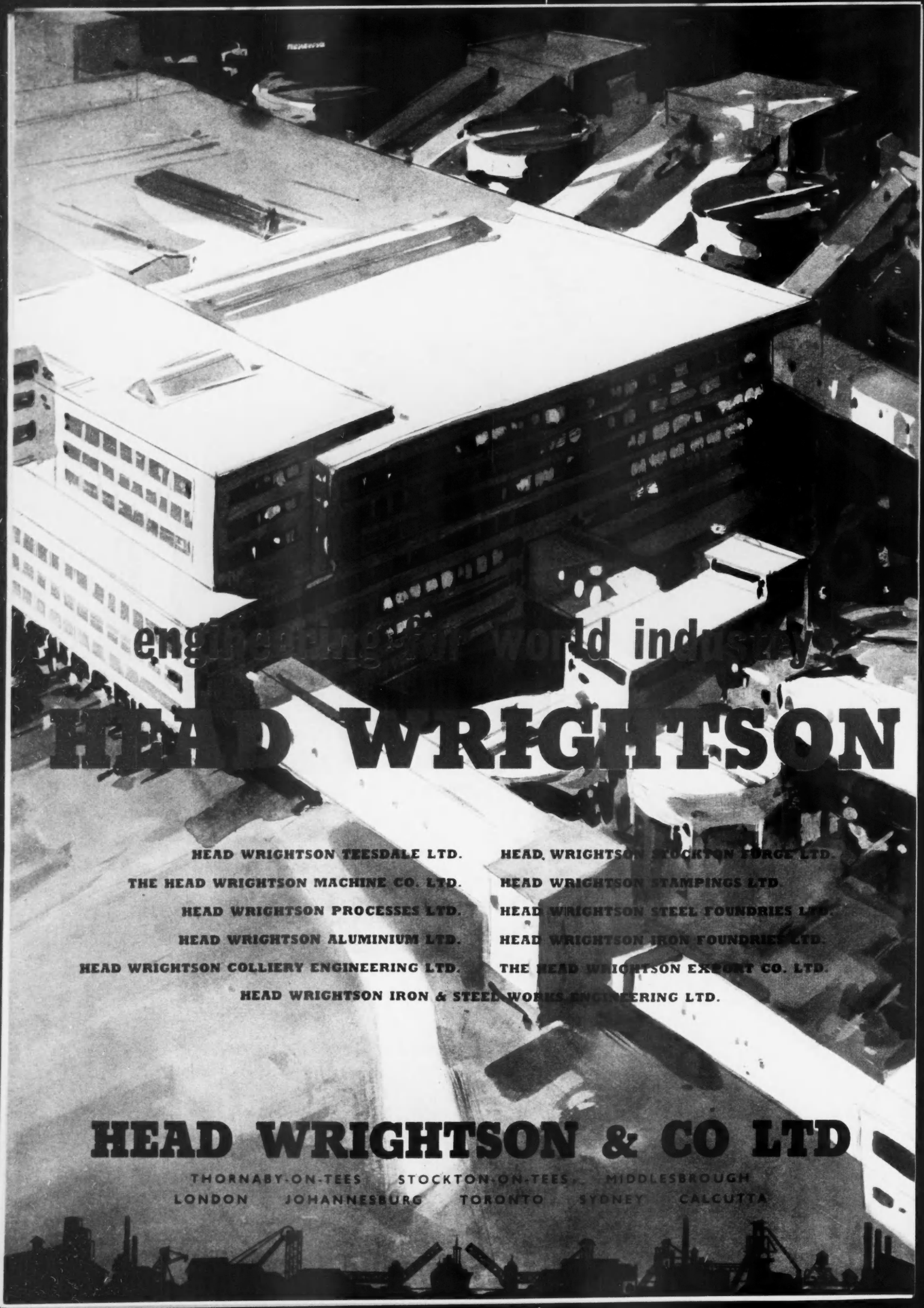

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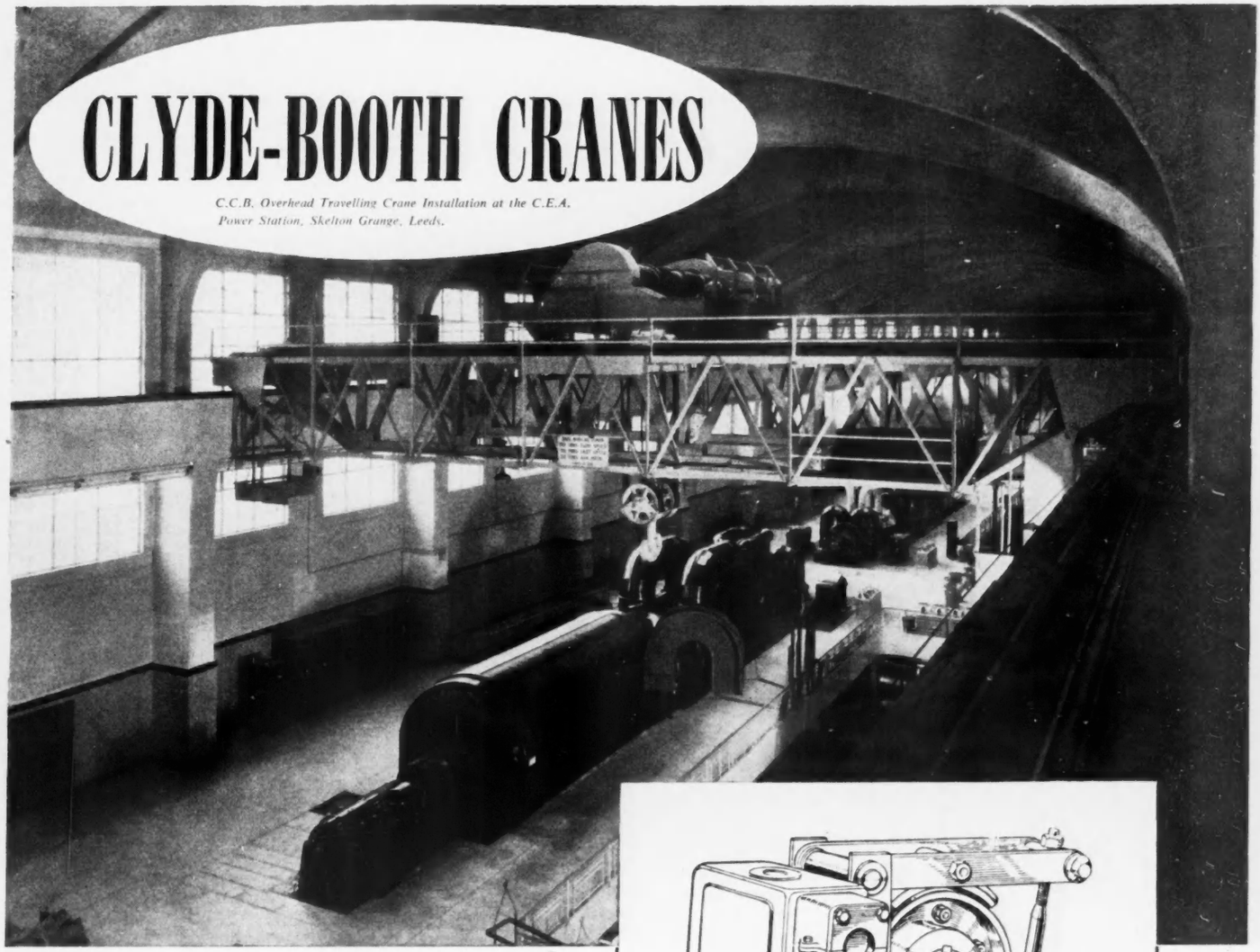

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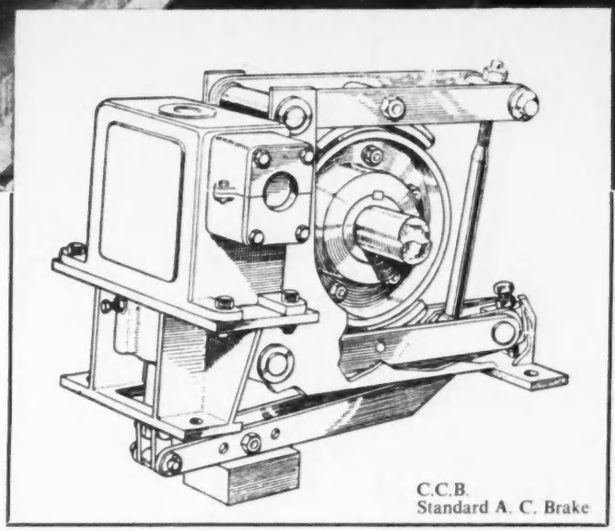

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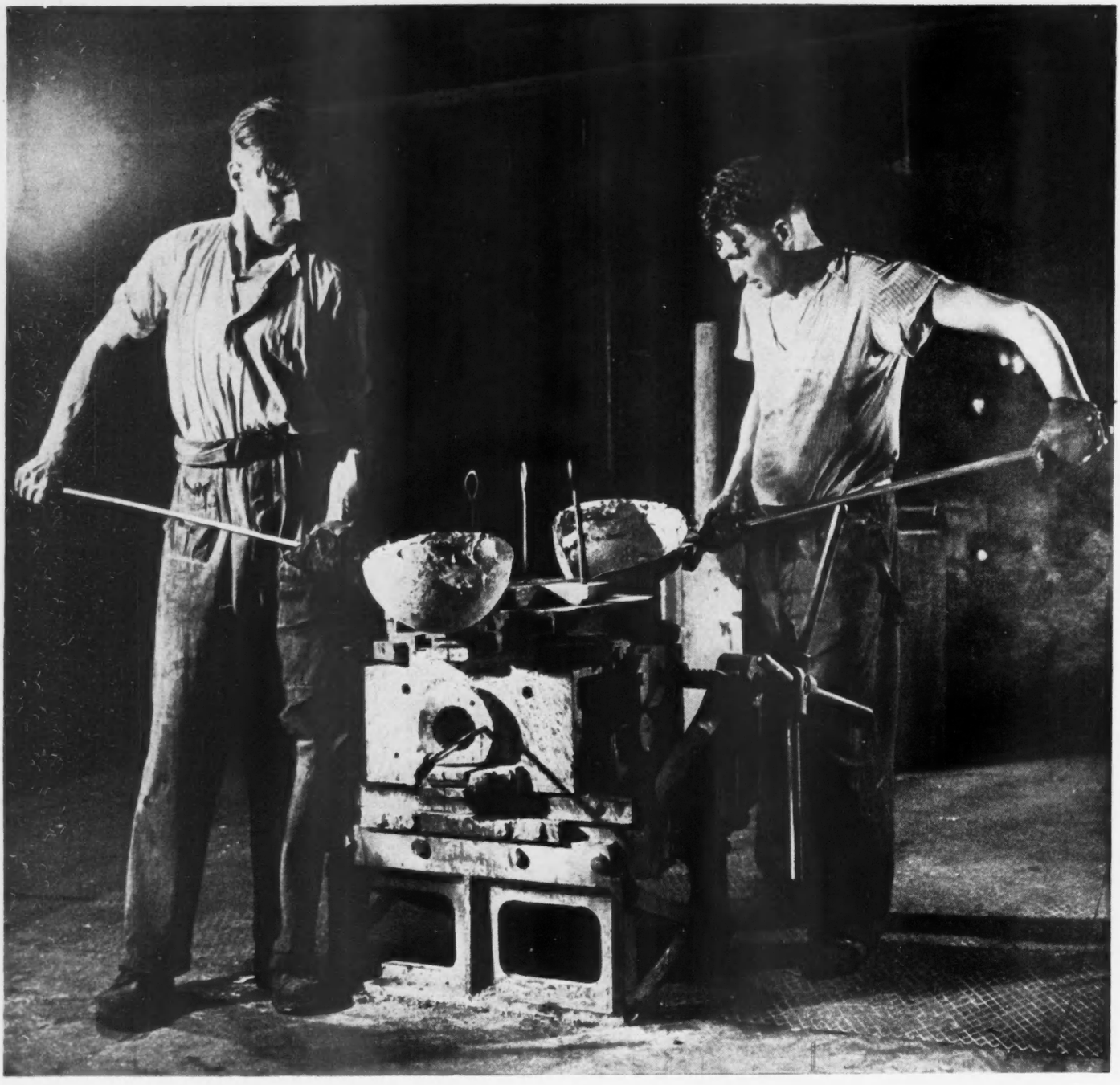

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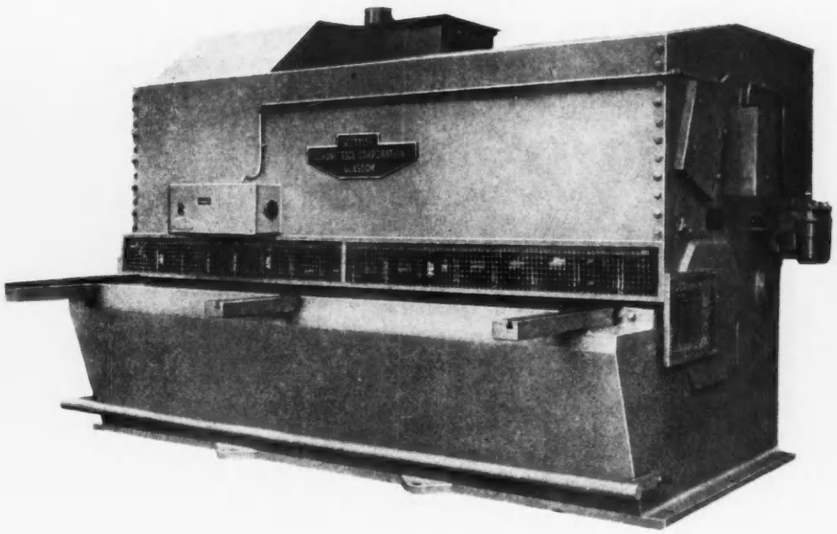

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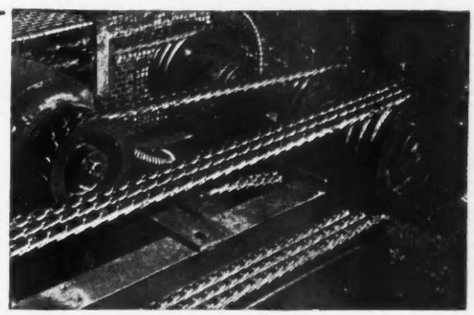

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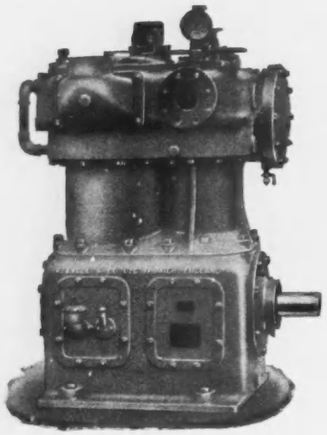

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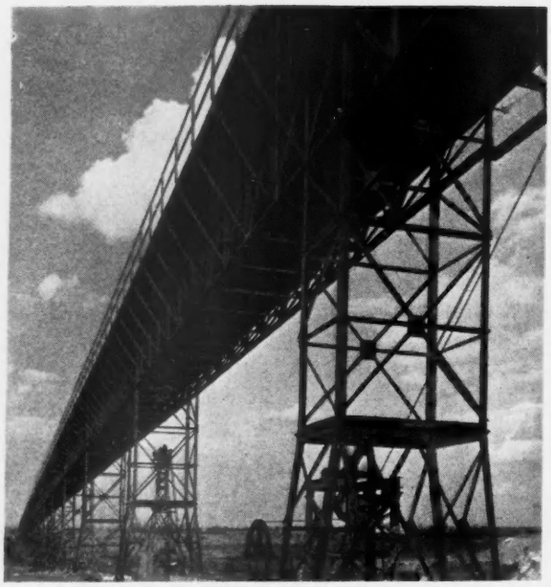

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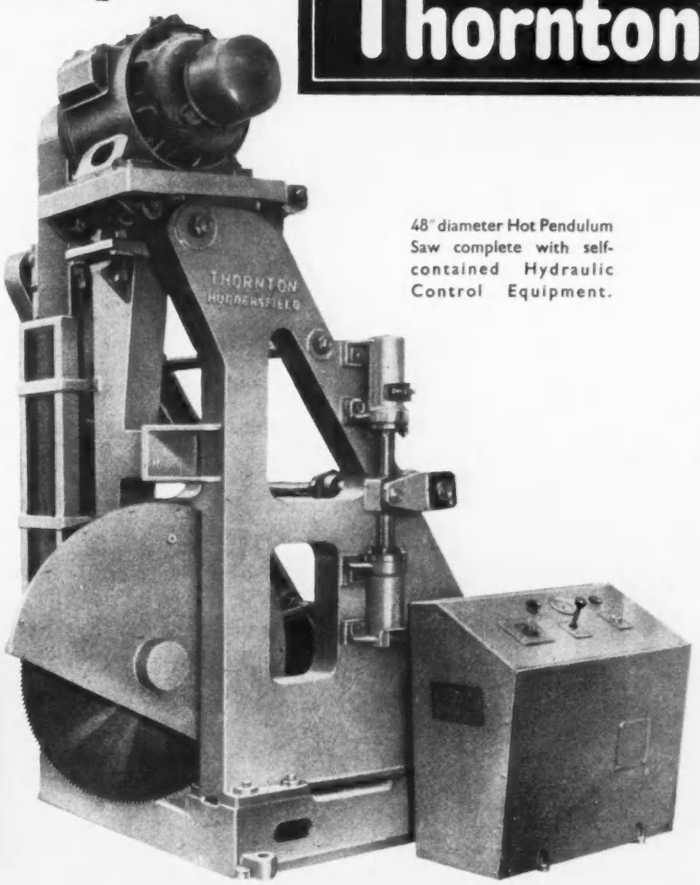

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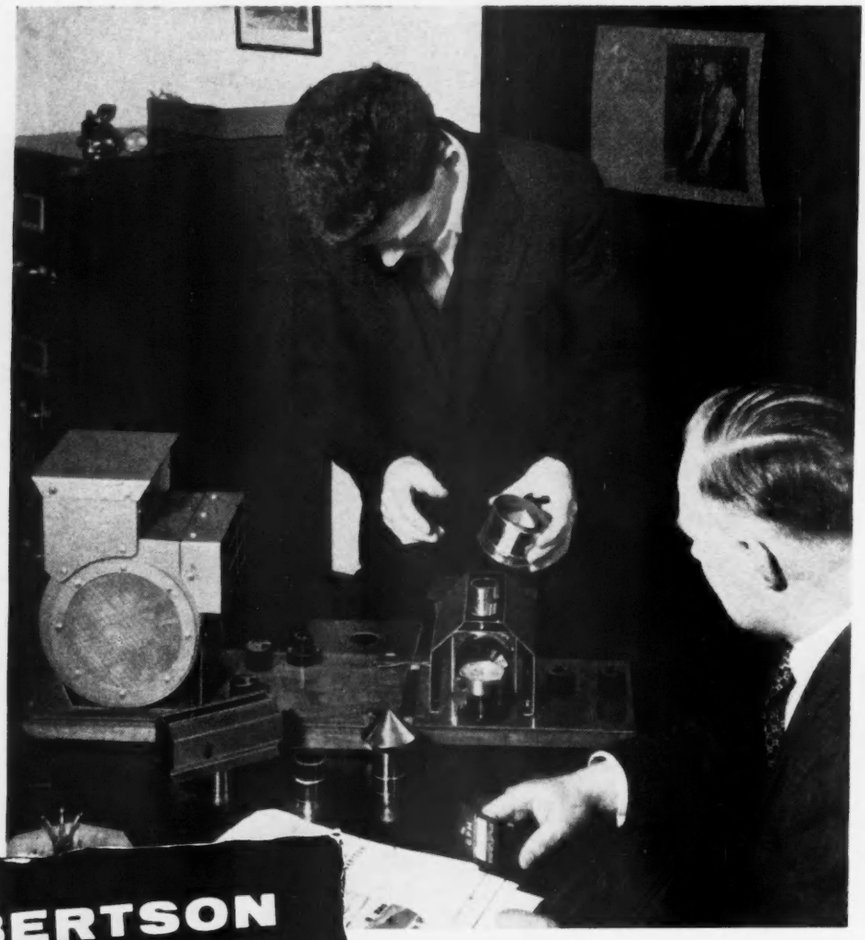

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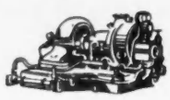

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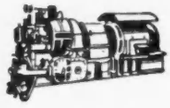

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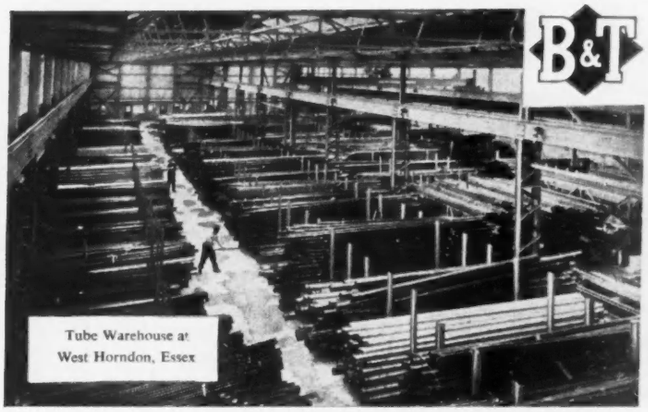

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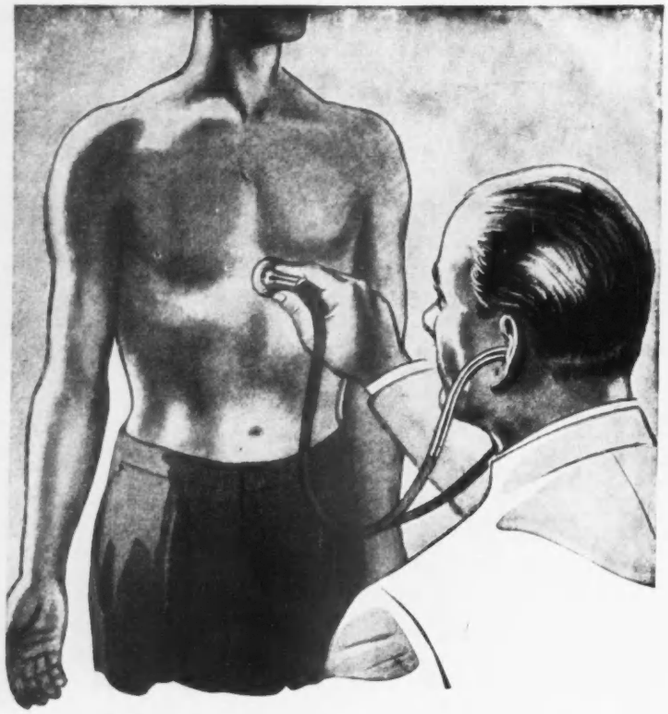

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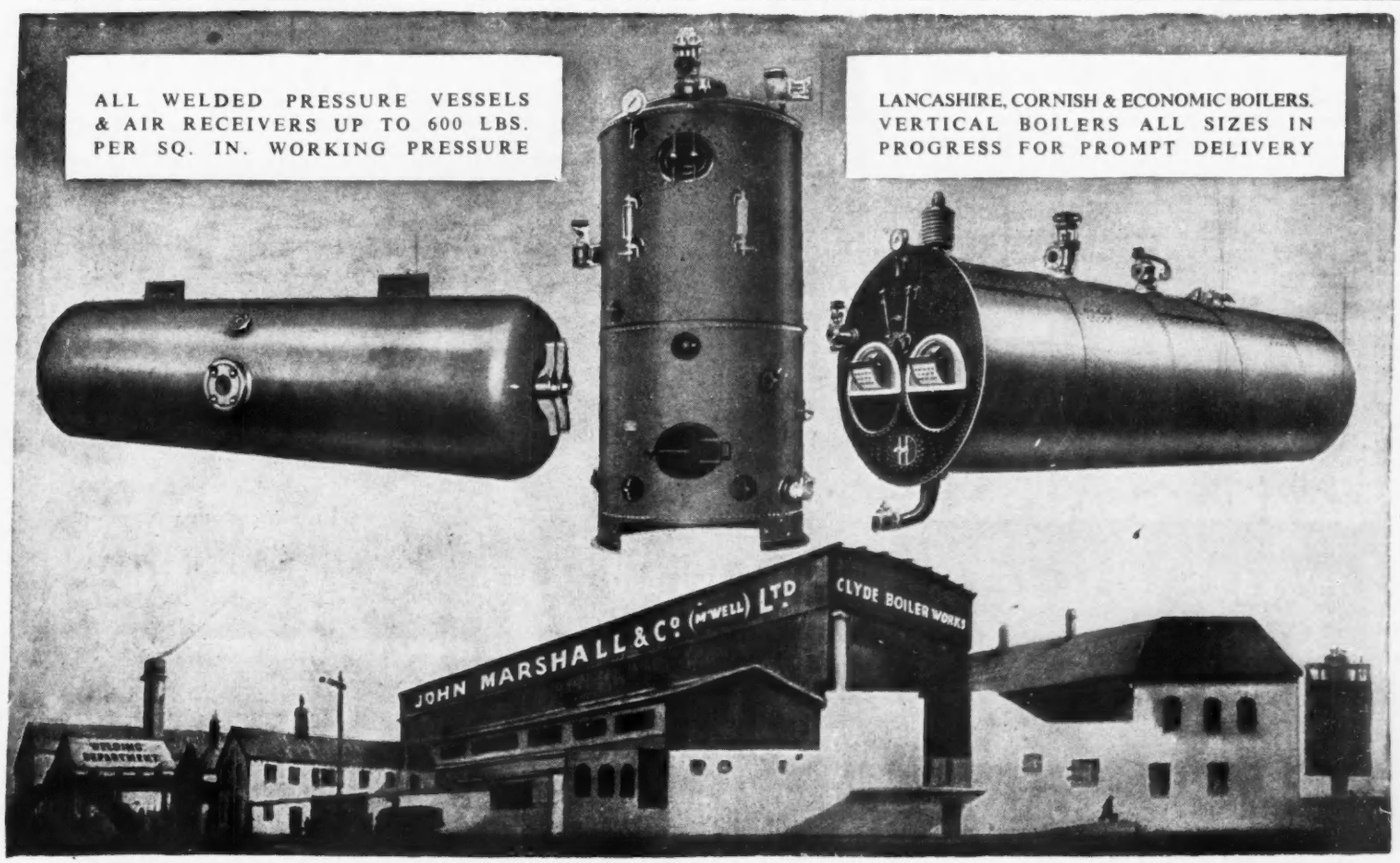
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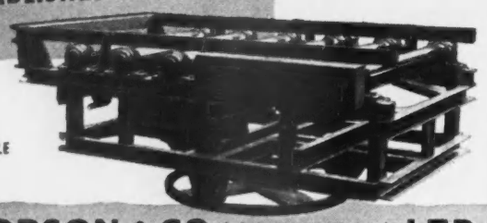

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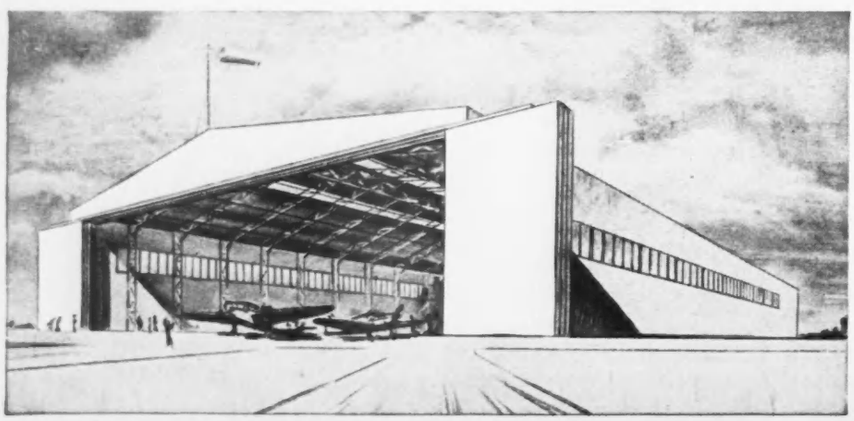

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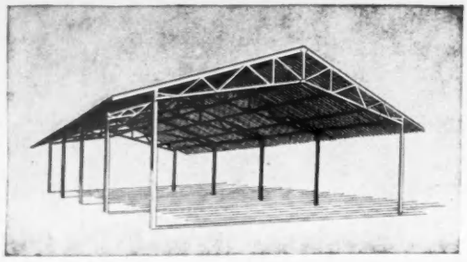

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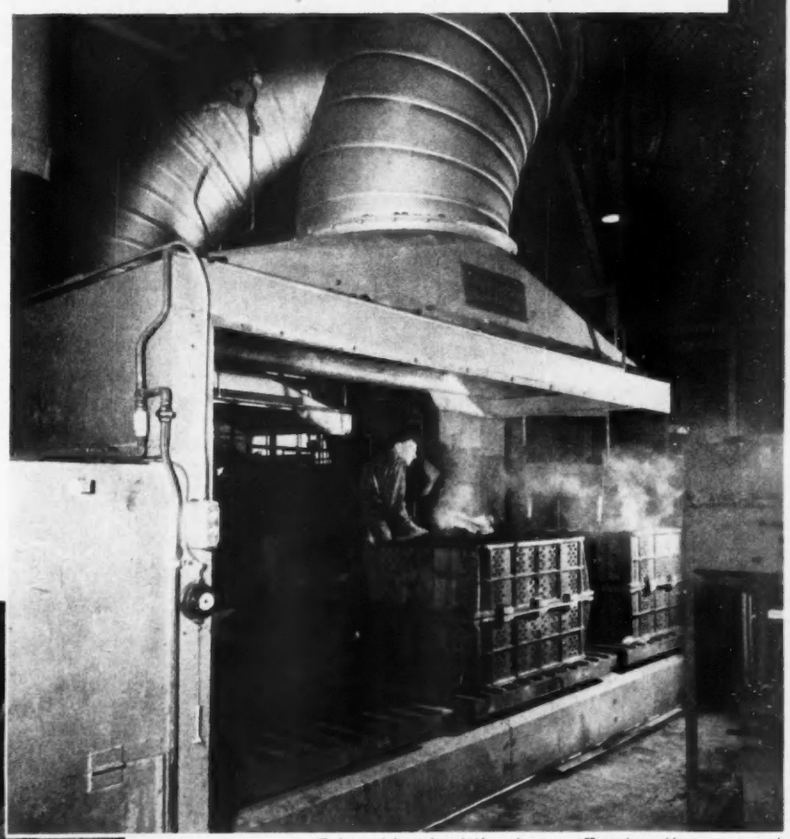
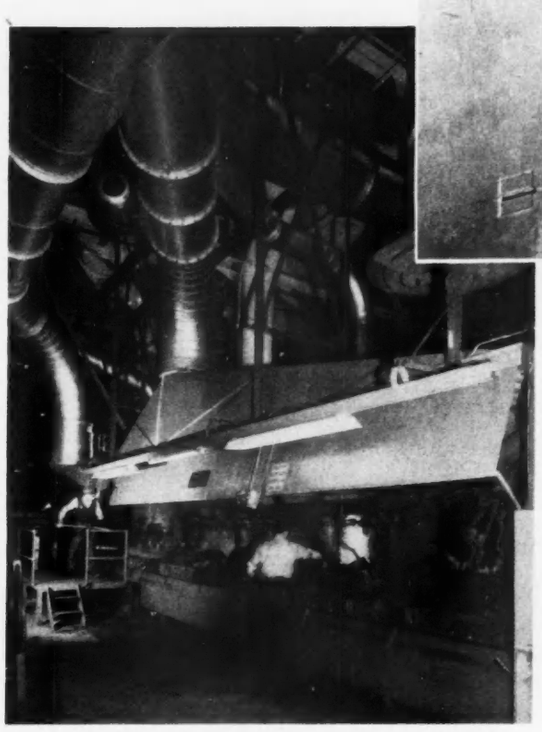


Exhaust hoods at the clamps off and castings removal stations. Photographs reproduced by permission of the Ford Motor Co. Ltd.



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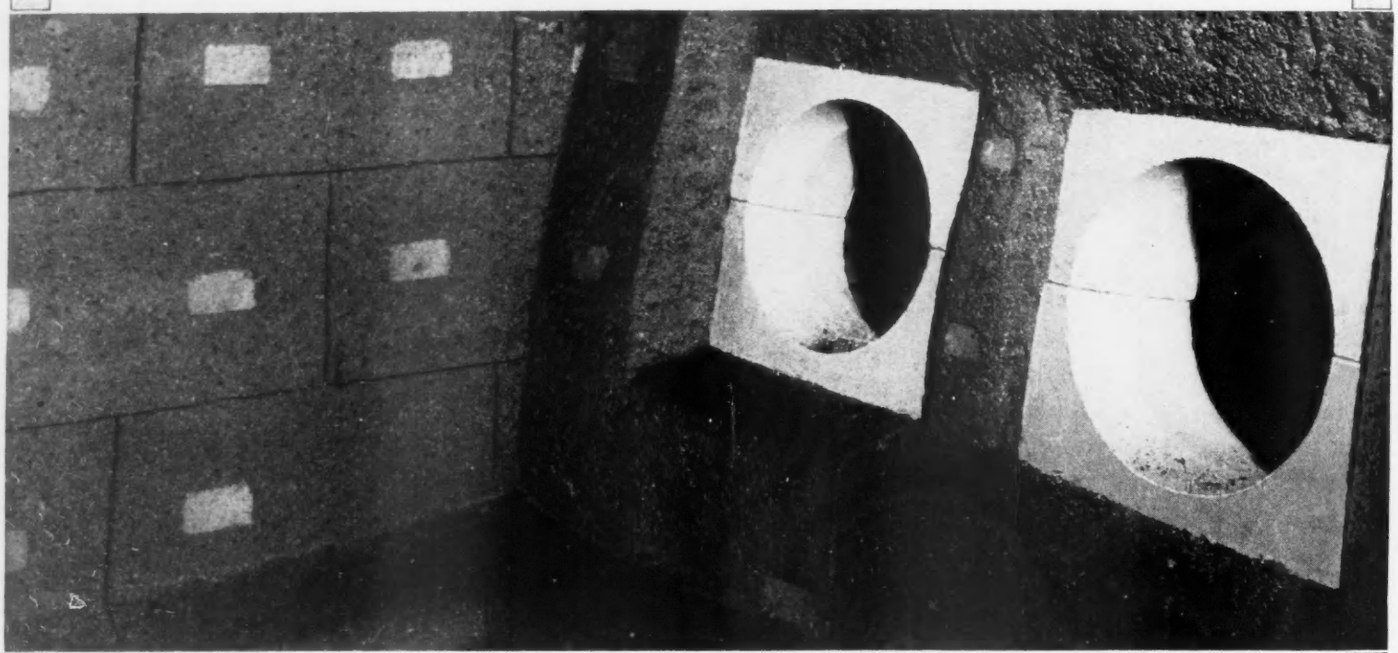

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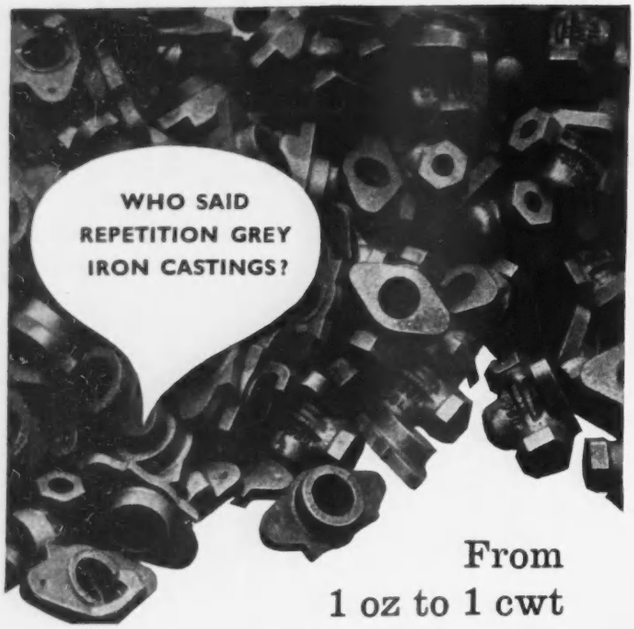

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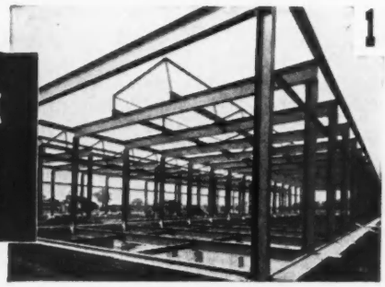
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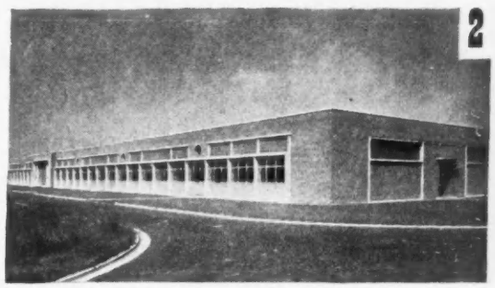
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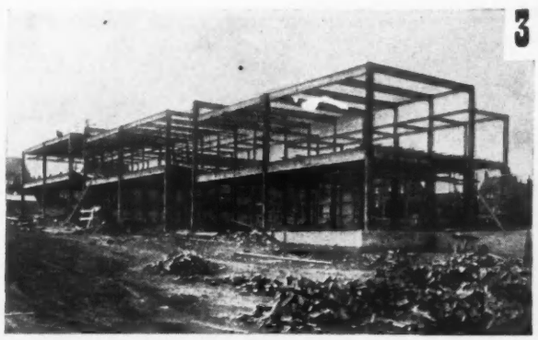
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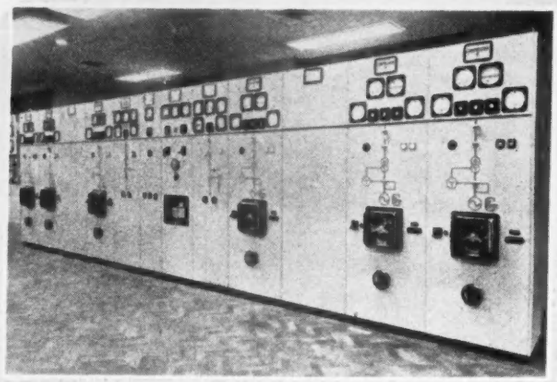

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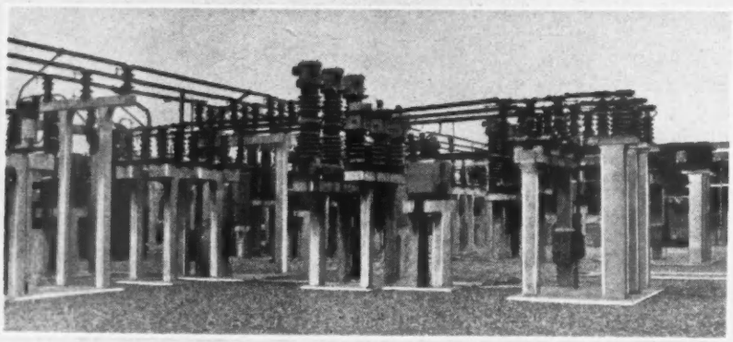

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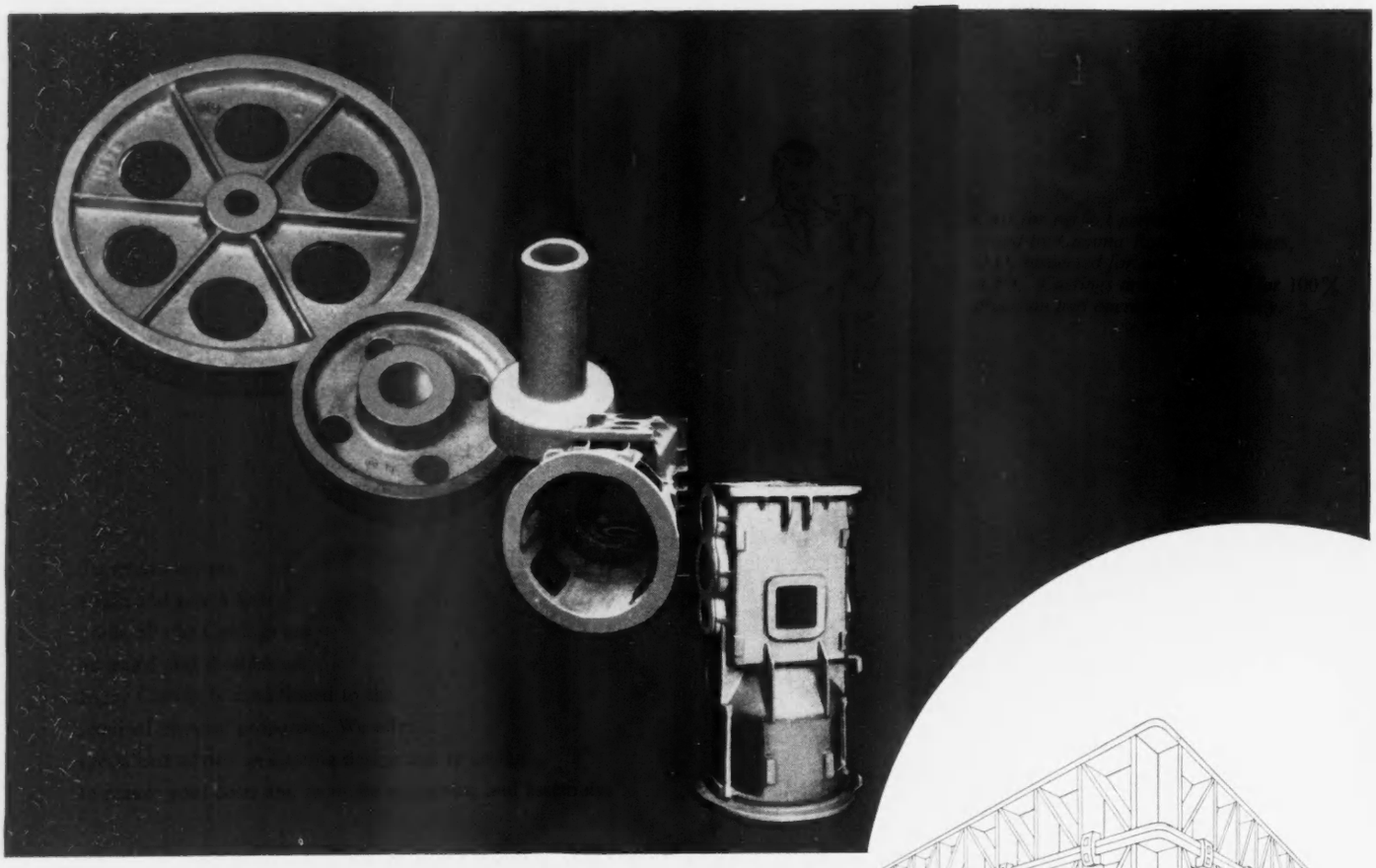

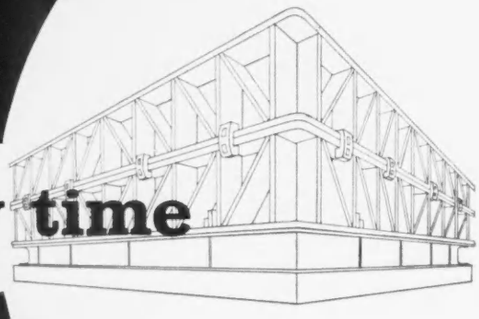

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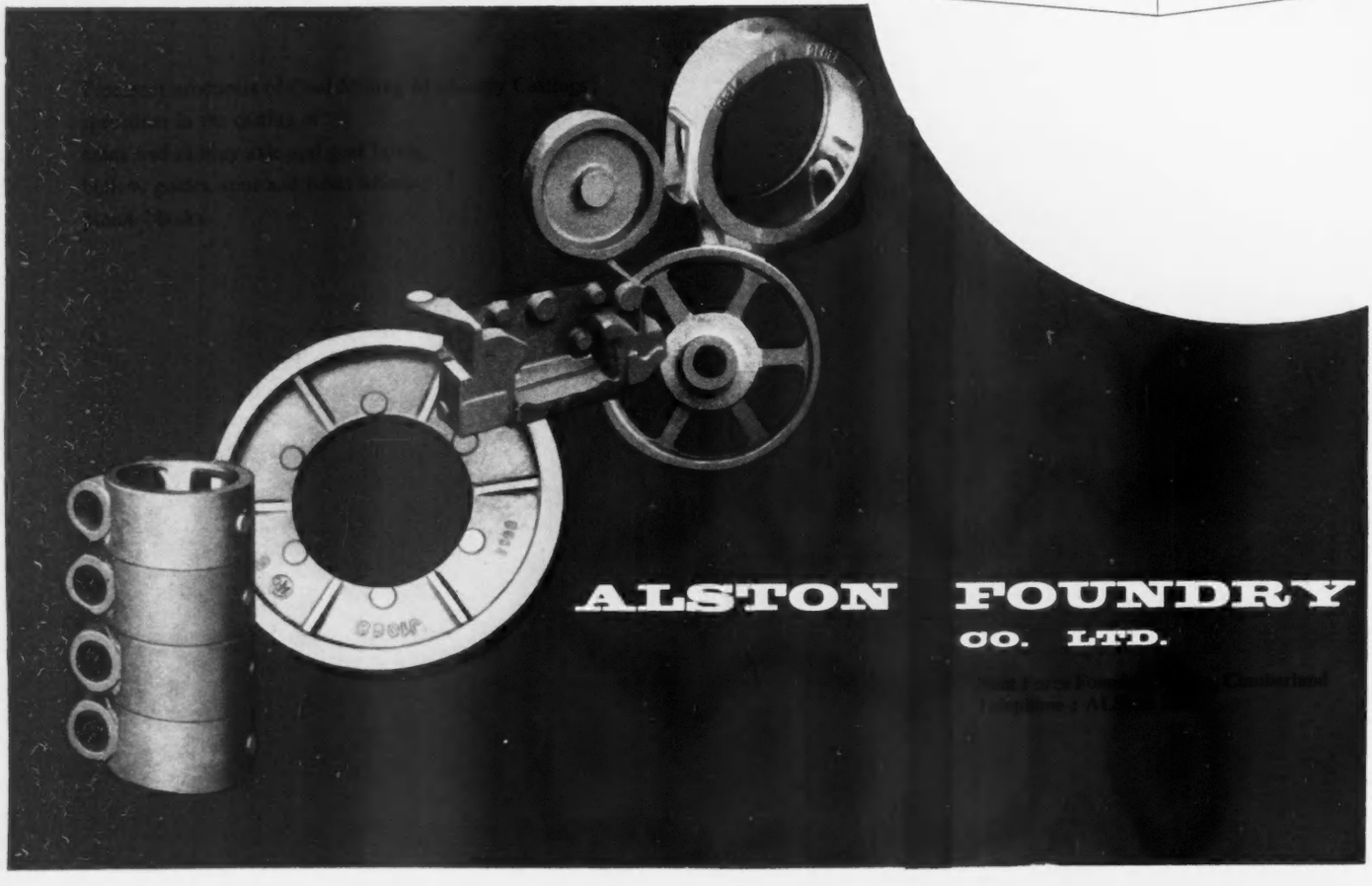

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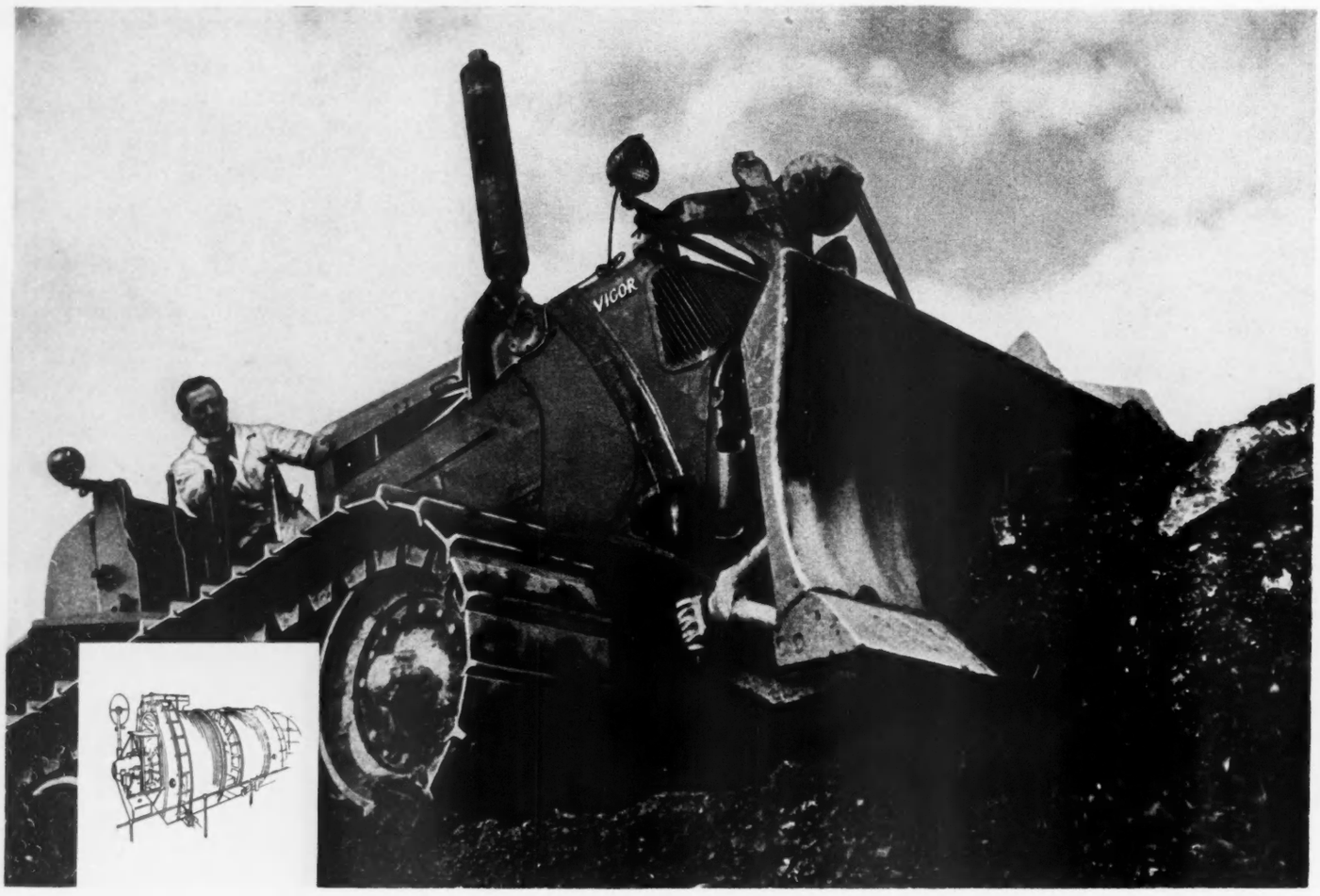

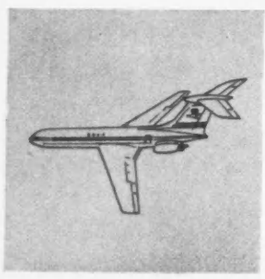

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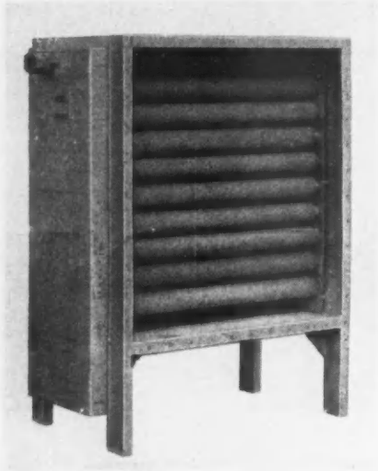

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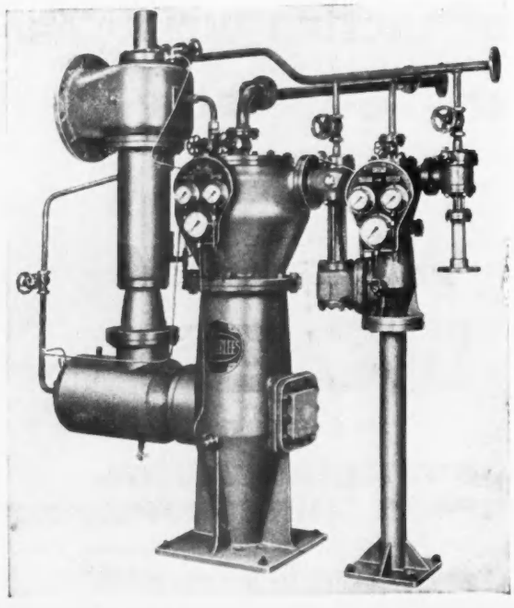

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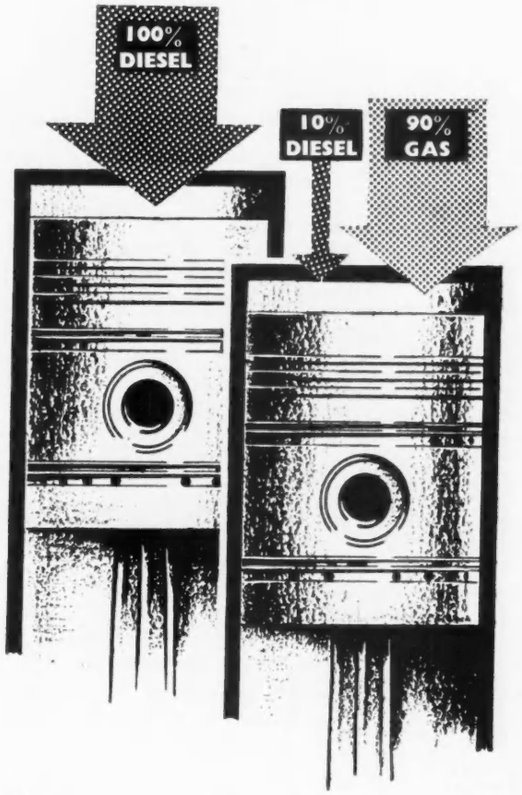

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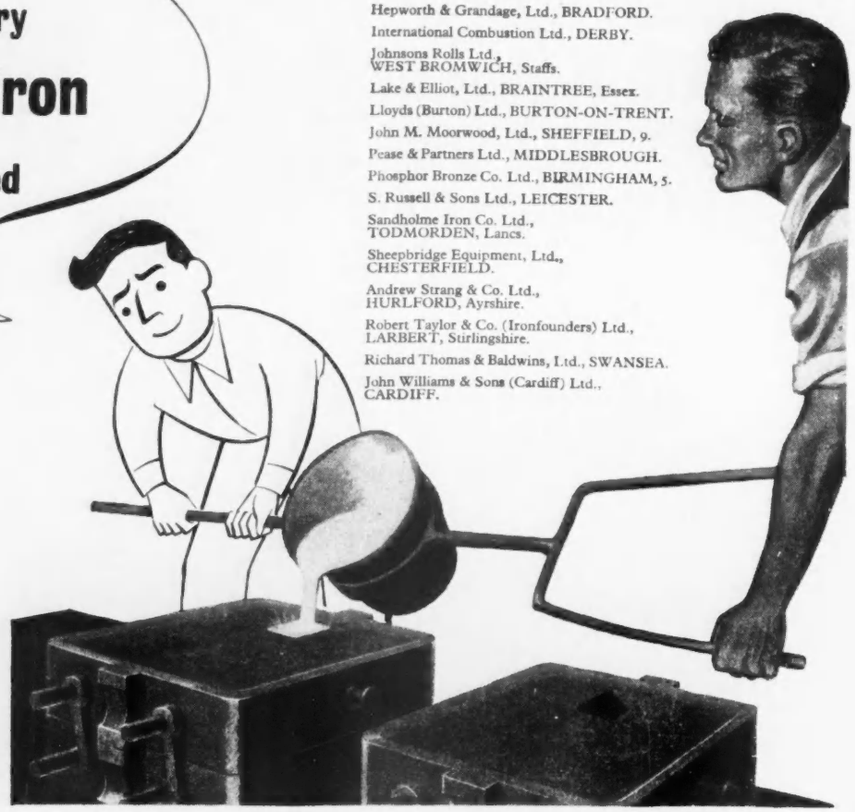

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THE ENGINEER

No. 5366 NOVEMBER 28, 1958 VOL. 206

OVERTAKING THE CAPITALISTS

Recently, Mr. Krushchev published a report giving outline plans for the expansion of output of various basic industries in the U.S.S.R. over the period 1959–65. The report will be presented and discussed at the Communist party's congress next January. It envisages considerable expansion in practically every form of industrial activity, and its dominant theme is that of racing ahead of the capitalist countries in *per capita* output. During this seven-year plan, the communists consider, Russia will overtake " the most highly developed capitalist countries of Europe "—Britain and Western Germany—in industrial output per head, and in about five years after 1965 (the seven-year plan is the first stage of a fifteen-year period planned for expansion) will surpass the United States. In fifteen years, it is prophesied, the most important industries will have doubled or trebled their output.

One or two of the figures given in the report for estimated 1965 production are as follows : pig iron 65,000,000 to 70,000,000 tons (65 to 77 per cent increase over 1958), steel 86,000,000 to 91,000,000 tons (56 to 65 per cent increase), oil 230 million to 240 million tons (more than 100 per cent increase), gas 150×10^9 cubic metres (500 per cent increase), electricity $500–520 \times 10^9$kWh (100 to 120 per cent increase). The overall plan is for about 80 per cent increase over 1958 in total industrial output. Changes in policy include a programme for altering the fuel balance, with emphasis on oil and gas production ; a concentration on large thermal power stations, at the expense of hydro-electric power (as explained in a " leader " a few weeks ago) and acceleration of the development of the chemical industry. Railways are to be electrified, or to have diesel locomotives ; the eastern regions are to be developed by opening up coal and oil fields, and aluminium deposits, and creating regional power grids. Machine tool output is expected to increase by about 50 per cent and light industries generally by about the same amount. Agriculture, and other activities not directly concerned with engineering, are given target figures with about the same degree of expansion.

These figures will be enough to show that the Russian approach to industrial progress is vigorous and business-like. Less would not now be expected of a country which has risen to such a powerful position and which has, at least in a fair measure, kept up with previous plans of this kind. But it should be pointed out that these plans are not quite so revolutionary as their instigators would have us believe. Industrial expansion in the West—and particularly in this country—goes on quite quietly, without attracting a great deal of public attention. In Russia, by contrast, these plans are an expression of faith—a justification of a political system. An industrial country of any size and power is a very flexible and adaptable entity, and if the need and the will exist, vast changes can be wrought relatively rapidly. Thus, from the more leisurely standpoint which is characteristic of this country—a standpoint which looks upon industrial activity as a service for the well-being of individuals rather than an expression of national aggrandisement—the feverish emphasis given to those plans seems rather hollow. The cow with the largest udder is not necessarily the happiest one in the herd.

But if the propaganda aspect of the plans is discounted completely there is equally no doubt that standards of living in Russia will be improved by their fulfilment. Such improvement is the least which should be expected from twentieth-century technology, but will probably still be limited in Russia by concentration on " strategic " industries. Furthermore, if we admit a " race " between the two systems—which we are disinclined to do, since it is a narrow-minded conception, and does not do justice at all to Western ideas—it still seems unlikely that Russia will overtake all her competitors, bar the U.S.A., by 1965, as Mr. Krushchev so confidently predicts. Two sets of figures may be taken to compare British and Russian aims. First, steel production, now teetering round 20,000,000 tons in Britain, will be 28,000,000 or 29,000,000 tons by 1962—a *per capita* rate around 25 per cent higher than the Russian target for 1965. And, secondly, electricity (the comparison is more complicated and less exact ; it is based on the C.E.G.B.'s area only); where the British *per capita* rate was between 30 and 40 per cent higher than the Russian for 1958, an expansion of 44 per cent in British installed capacity is planned by 1963. This compares with the 100 to 120 per cent increase in units generated planned for Russia, and seems to bring the British 1963 rate to about the same as the Russian 1965 one. All this comparison, of course, completely neglects the fundamentally different economies of the two countries : Britain imports most raw materials and must live by exporting, whereas Russia's indigenous wealth of practically all raw materials is enormous. This fact, combined with the tight central control of her economy, would seem to remove most obstacles to rapid expansion.

In conclusion, one or two aspects of the Russian plan relating more directly to engineering are worthy of comment. Water power construction is virtually abandoned (Stalingrad, the even bigger Bratsk scheme and three others are to be completed) to get quicker results with steam stations. Nuclear stations are to be built, but no figures are available and the policy of abandoning the heavy capital charges associated with water power obviously would not encourage nuclear stations ; British nuclear projects are incurring onerous capital expenditure now, with prospects of greater gains in the future. Other developments in oil, gas and aluminium would seem to be based on newly-discovered natural resources. Apart from these, the plans for the chemical industry are striking, calling for 140 new works, modernisation of 130 others, and overall a trebling of output.

SEA-BORNE ROCKET SITES

When outlining its five-year defence plan in last year's Defence White Paper, the Government emphasised that the free world to-day is mainly dependent for its protection on the nuclear capacity of the United States. But it would have saved itself much criticism if it had explained why " there is a wide measure of agreement that Britain should have an appreciable element of nuclear deterrent power of her own." Clearly, if this country is to have an effective influence on N.A.T.O. policy and to have some say in the selection of targets in the event of war, we must contribute some share of the allied deterrent. But there is much more to it than that. A substantial portion of the United States Strategic Air Force consists of medium range bombers based on this country. In whatever state of alertness these bombers are maintained, a surprise attack might well destroy many of them on the ground, and the airfields from which they operate. To add to their numbers by building British V-bombers, it is argued, is thus a wise precaution. A new problem has, however, arisen in the need to supplement—and in course of time to replace—these bombers with medium range ballistic rockets, sites for which it is hoped also to erect in Western European countries and North Africa. The safety—and in some cases even the availability—of these rocket bases thus becomes a question of the highest importance. All of them are well within range of Soviet ballistic rockets launched from the satellite countries. No less serious are the threats and blandishments of the Soviet Government warning the Western European nations of the consequences of allowing American rocket bases to be established on their soil. The results of this unrelenting Soviet pressure may be seen in the anxiety for a "summit" conference and in the protests against the erection of rocket sites—protests which are much more in evidence and more effective in Western Europe than in Britain.

None the less, the British people and the nations of Europe are behind their Governments in believing that their safety lies in making the certainty of retaliation an ever-present fear in the minds of the Soviet leaders. But they can be by no means convinced that these medium range weapons—both bombers and rockets—will not be eliminated by surprise attack. While concealing the positions of their own rocket sites, the Russians are bound in course of time to find out the exact position of all the airfields and rocket sites erected in democratic countries. Thus, neither the " Thor " sites above-ground nor the forthcoming British " Blue Streak " rocket sites underground will be safe from Soviet rocket warheads set to explode on landing. The crater formed by a thermonuclear explosion would effectively prevent further use of the site. The United States Defence chiefs have always been apprehensive about the availability of their medium range retaliatory power. To off-set this danger, Congress has already authorised the building of six super aircraft carriers of 60,000 tons, capable of launching, from positions off an enemy's coast, heavy bombers with a 1000-mile range. And since the missile era, the Americans have supplemented the carriers by arming cruisers and some of their large submarines with guided flying bombs of similar range. More recently they have also started building submarines capable of launching, when submerged, up to sixteen " Polaris " ballistic rockets with a range of 1500 miles. It is indeed extraordinary that Britain—which has relied for her safety on sea power for the past 400 years—does not seem to appreciate this obvious solution of seaborne rocket sites. Their mobility ensures safety from attack by rockets, which must be preset to strike a fixed target of known location. The possibility of surprise attack by any other means—entailing the search, tracking, approach and attacking of naval units—could well be accepted by a belligerent with the surface command of the sea. Seaborne bases are in fact the only bases available for medium range retaliation which are immune from surprise attack—and attack on which, incidentally, would not result in the devastation of allied territory. We have not the finances to build carriers costing £70,000,000, nor very large submarines costing £30,000,000, for the sole purpose of launching ballistic rockets. But rockets have no recoil and need require no vast shipboard installation for their launching and guidance. Britain should build new ships of carrier and cruiser classes—both to carry out their primary duty of protecting the sea communications and as seaborne sites for the " Polaris " rocket. Moreover, if it is still considered necessary to duplicate the American effort by designing a British longer-range rocket—such as the " Blue Streak "—it should be designed for use at sea.

JODRELL BANK AGAIN

Since it approached completion rather more than a year ago, the great radio telescope at Jodrell Bank, erected for the use of Manchester University, has seldom been out of the news for long. In July, 1957, we and other interested technical journals were able to publish complete accounts of its structure and mode of operation. Some six weeks later, the Committee of Public Accounts expressed strong criticism about its cost, and about the behaviour of the D.S.I.R., Husband and Co., the consulting engineers for the work, Professor Lovell and Manchester University, without, it subsequently appeared, having had the full facts placed before it. In October the device was hastily adapted to keep track of Russia's first " Sputnik," so unexpectedly put into orbit at that time and so unexpectedly large ; and in November it was helping to keep track of the movement of yet another Russian " Sputnik," this time weighing half a ton. Since then, as the Russians have continued to place artificial satellites into orbit and as the Americans have joined in, the services of the telescope have repeatedly been called upon for tracking purposes. Only within the last few weeks the telescope was helping to plot the orbit of the first " lunar probe " which, after it had been successfully launched by the Americans, penetrated 79,200 miles into space before returning to burn up in the earth's atmosphere. Much less has been said about the work it is doing in other ways, for which it was primarily designed and for which it has already shown itself to be peculiarly well adapted. Now, as will be seen from an article on page 842 of this issue, the telescope is once more in the news. Sir Raymond Street made special mention of it in his chairman's speech to the Court of Governors of the University of Manchester. The heat generated by the criticism by the Committee of Public Accounts seems to have been dissipated. But it remains as a fact—now no longer regarded by anybody as at all discreditable to anyone—that the telescope cost substantially more than it was originally estimated it would cost. The University is to make an appeal with the object of meeting that part of the cost which has not yet been met. Two industrial firms, Henry Simon, Ltd., and Simon-Carves, Ltd., have already contributed generously and Sir Raymond acknowledged also that the main contractors for the work, the United Steel Companies, Ltd., rated the final achievement " much above purely financial considerations." As Sir Raymond put it, the University feels " there will be many who will be extremely keen on this great national achieve-

ment . . . . . and will be ready and willing to help the University to wipe off what is relatively a small debit balance." Sir Raymond remarks that the University Treasurer is already provided with a book of receipts.

WATER SUPPLY PROBLEMS

In a speech at the Annual Dinner of the British Waterworks Association on November 12, Mr. Henry Brooke, Minister of Housing and Local Government, was at some pains to defend his Ministry against those who advocate the setting up of a Ministry of Water Supply, the nationalisation in some form of water supply, or the creation of some central body with general jurisdiction over the water supply industry. He mentioned that under the Water Act of 1945, he and his predecessors had been encouraging the amalgamation of water supply undertakings and occasionally using compulsory powers to bring them about. In 1945 there were no less than 1250 separate water undertakings in England and Wales. But, to-day, there are still 969 ; and even though, to quote the Minister, " proposals affecting ninety of those 969 undertakings are embodied in draft orders now before me, or in Private Bills " ; and even though another 150 undertakings have agreed in principle to regroup into " about " thirty-seven larger units and the remaining 700 or so " are actively discussing the problems and possibilities," it is very difficult to regard progress as even reasonably fast. The kind of target at which the Ministry should be aiming was suggested the following night by Mr. Noel Wood. In a paper presented before the Public Works and Municipal Services Congress, he estimated that about 100 water supply units would be a suitable number, under national control. But at the present rate of progress it is very clear that the reduction of the number of undertakings to that degree must take a very long time indeed ! What those concerned with water supply believe they see more clearly than does the Ministry is that, though to talk of an unco-ordinated scramble for water amongst water undertakings is an exaggeration, it is still true that the exploitation of possible sources needs better and more overall planning than it gets at present. Policy in that respect needs to be co-ordinated within the whole watersheds of this country's larger rivers and much more complete consideration needs to be given to the effects of transferring water from one catchment to another. Pollution needs more actively to be fought ; and the whole question of water abstraction and water treatment is necessarily linked up with policies of sewage disposal. Wisely regulated and conserved, there can be no doubt that there is plenty of water in this country to serve all purposes. But many water engineers find it difficult to see how there can be wise regulation and conservation without some central and national body whose sole function it would be to bring it about.

COMMENTS ON THE JOB

One so often hears it suggested that men in the works are anxious not to work and trying perpetually to find ways of slacking that it is refreshing to find in a report of the National Institute of Industrial Psychology that, in fact, the employee's greatest interest is in getting on with the job without needless hindrance. The relevant report is entitled " Comments on the Job." The Institute's investigators went to six factories varying in size, age, traditions, working conditions and product ; they invited employees to come and tell the investigator, in confidence, anything they liked about working conditions. Some of the results are curious. Why, for example, do complaints of poor ventilation turn up so regularly ? Two of the surveys were made in engineering factories, two in textile factories, one in a mineral fibre processing factory and one in a confectionery firm. There seems no reason in so varied a lot why poor ventilation should prove a common factor. In all factories there were remarks about inadequate definition of responsibility and authority. But that is a kind of complaint that must always be expected. For even in the military sphere where definition can be much more precise there is a good deal of grousing on this subject. In civil employment nothing so rigid can be tolerated. It follows that the degree of responsibility and authority held by any man is partly a matter of his own choice. Again the complaint of lack of information from the management is one that it is far less easy to remove than it may seem to be to an employee on the shop floor. For managements, like people, take time to make up their minds and quite often change them ! It is not easy in these circumstances to keep everybody right " up to date." Another frequent source of complaint related to lack of proper liaison between shifts or between departments. Can this source of complaint ever be removed, we wonder ? For nobody ever really believes that his opposite number on another shift is as careful and tidy as himself ! The two of them meet too seldom to gain that appreciation of somebody else's character which comes from frequent contact with him. All kinds of other subjects were raised by the 1678 employees whose comments were recorded, some of whom were managers as well as operators ; and the report should be of interest to managements of firms of all kinds by indicating the relative importance in men's minds of a variety of factors affecting their happiness and efficiency at work.

The Engineer—100 Years Ago (NOVEMBER 26, 1858)

" Hydraulic Graving Docks"

" The hydraulic graving docks, which have been in construction for the past two years, in connexion with the Victoria Docks, are now completed, and are understood to have proved successful. They are upon the principle patented by Mr. Edwin Clark. When a vessel is to be taken up, a broad, iron flat-boat, or ' saucer,' as it is called, is sunk in the bottom of the dock, which is only an open excavation in shore from the river and without gates ; the vessel is then floated over the saucer after which both are raised together by a connected series of hydraulic lifts, until the saucer is entirely out of the water. The water with which it was filled having run out as it ascended, the saucer is then made tight, and with its new burden is floated off to one of several shallow basins, where all necessary operations can be carried on with the aid of workshops alongside. The principal basin, in which the vessels are lifted out of water, is about 300ft. long, with, perhaps 20ft. depth of water ; its sides being sloped at about two horizontal to one perpendicular, and pitched with stones.

" Along either side is a row of sixteen hydraulic cylinders, each about 4ft. in external diameter, and having a lift of about 22ft. These cylinders rest upon a firm foundation, while a cylindrical shell, slotted at the sides, and of nearly 25ft. in height, is continued above each of them to serve as a guide for the cross head of the pistons. These cross heads are of wrought iron, and are each connected by links to a pair of wrought iron beams, of which there are altogether thirty-two across the basin, and by which the flat-boat or saucer, under which they pass, is lifted out of the water. All the hydraulic lifts work simultaneously from the same engine and pumps, so that the rising motion is perfectly uniform. It is stated that, on the first trial, a vessel of 600 tons was raised to its required position in thirty-five minutes, while it is expected that vessels of 2,000 tons can be raised, examined, and again let down in six hours."

Electronic Computer Exhibition

No. I

The first comprehensive exhibition of electronic computers to be held in Europe opens in London to-day (Olympia, November 28 to December 4, 10 a.m. to 8 p.m., excluding Sunday). More than forty firms are taking part in this exhibition, which emphasises the rapid progress that has been made in Great Britain in developing a great variety of computers and applying them to commerce and industry. Many computers will be seen in operation. A symposium of twenty-four papers on the computer as an aid to management is being held during the exhibition to enable potential users to benefit from the experience of actual users. The exhibition and symposium are being organised jointly by the Electronic Engineering Association and the Office Appliance and Business Equipment Trades Association.

THE electronic computer exhibition and business computer symposium, which are being held at Olympia, London, from to-day, November 28, to December 4, illustrate the great strides that have been made in the industrial and commercial application of computers in Great Britain. They also show the enormous scope that still exists for further widespread application.

There are more than 100 computers known to be operating in this country. Their users include British Railways, the National Coal Board, local governments, insurance companies, banks, merchant houses, manufacturers and research establishments. But it is no exaggeration to state that the use of computers could be much more widespread and that there are many smaller businesses which could benefit in efficiency by the intelligent application of computers.

Many computers can be seen in operation and studied closely at the exhibition. What is equally important is that the business computer symposium which is being held simultaneously will give potential users a chance of learning from the first-hand experience of those organisations that are already operating computers successfully. Twenty-three papers are being presented at the symposium, covering the use of computers for compiling payrolls, production planning and management, public utility accounting, banking and insurance transactions, stores and inventory control, research and design.

In one of these papers, for example (to be read on December 1) the planning of tubing manufacture using an I.B.M. 650, will be discussed by R. G. Hitchcock, Tube Investments, Ltd. In this organisation the computer has been programmed to accept orders for various kinds of tubing, to specify the most economical raw material to be used and the detailed method of treatment, and to prepare the manufacturing documents for the job. Another paper, by R. B. Baggett, of Job White and Sons, Ltd., and G. M. Davis, of the English Electric Company, Ltd., gives an example of the way in which a small firm (in this case a textile factory) can improve production control by buying computer time.

As for the exhibition itself, the computers and auxiliary mechanisms exemplify the technical progress that has been made in the past decade or so. In many instances, valves are giving way to transistors. Improved memory devices are to be seen. Ferrite cores are being introduced for storage and logic systems. Printed circuits are adopted widely. The variety of computers designed to suit different classes of users has increased greatly. The speed of computers has been raised and so has the speed of an important auxiliary, the print-out machine, which usually limits the overall speed of the installation.

Some exhibits, embodying advances such as these, are described and illustrated below.

Ferranti, Ltd.

The various aspects of data processing systems and digital computers for applying these systems are very well exemplified by Ferranti, Ltd., Hollinwood, Lancs, which claims to be the first company anywhere to market computers commercially. An unusually wide range of requirements is covered by the Ferranti exhibits which deal with the "Perseus" data processing system, the "Pegasus" Converter and Direct processing systems, the "Mercury" computer, the "Pegasus" computer and the computer control of machine tools.

The "Perseus" data processing system, which is being exhibited for the first time, is intended for use by large commercial establishments such as insurance companies, public utilities, government departments—in other words, organisations whose work involves mass communication with the public, the maintenance of files containing millions of items and the printing of many thousands of documents. In organisations such as these a great deal of alphabetic-numeric information has to be handled and, although the processing of data is mathematically trivial, it usually entails many complexities in logic and organisation. The "Perseus" data processing system is designed for such requirements, and has a capacity for 2048 words of twelve alpha-numeric characters. It can carry out mixed radix arithmetic and can handle directly sterling and decimal data. With its facilities for field selection, it can operate on parts of a twelve-character word. There are up to sixteen magnetic tape units, controlled through four buffer stores for simultaneous processing; each reel can hold more than 2,300,000 alpha-numeric characters. Built-in checking of all arithmetical and magnetic tape operations is provided. Two punched card inputs are available and there is provision for paper tape input and monitoring teleprinter. Output is from an off-line magnetic-tape-operated "Samastronic" printer.

The store is in two parts: the computing store of the central unit and the magnetic tape main store. Information is transferred between them by means of tape control units which contain buffer stores, to act as waiting-rooms between the computer and the magnetic tape mechanisms. Data are transferred in blocks of thirty-two words. The time for the transfer of a block from magnetic tape to the buffer store, or vice versa, is 75 milliseconds and all magnetic tape operations are autonomous. In the first "Perseus" to be built the computing store has a total capacity of 1024 words arranged in thirty-two blocks of thirty-two words each. It consists of wire delay-lines of three parts. To the programmer they appear as a single large capacity computing store (i.e. with a single system of addressing the registers); the three parts, however, have particular properties. (1) Thirty-two special registers which include, for example, the accumulators and the registers associated with multiplication and division, the radix registers, and registers used for field selection, modification and counting. (2) Four blocks each of thirty-two words stored in single-word lines—these blocks are used for storing information to which immediate access is essential. In most applications this will be the data next required. (3) Twenty-seven blocks each of thirty-two words stored in sixteen-word lines—these blocks are generally used for storing the parts of the programme currently being obeyed; more programme can easily be brought in from magnetic tape.

The main store consists of up to sixteen

Fig. 1—The "Perseus" computer. In the centre is the basic computer, which partly obscures a cabinet containing the power supply. In the foreground, left of the desk, are six of the magnetic tape control units. The punched card reader is in foreground, right, and beyond are the control units for magnetic tape and punched card—Ferranti

magnetic tape mechanisms grouped in fours, each group of four being under the control of one tape control unit, which contains a buffer store. The magnetic tape is ½in wide and is supplied in reels each containing up to 6200 blocks, i.e. 2,380,800 alpha-numerical characters.

" Perseus " is built up of " packages " or plug-in units (Figs. 1 to 3) which can be removed for servicing.

As with other Ferranti computers, optimum programming is unnecessary, for the orders are obeyed in the sequence in which they are written (unless a jump to another part of the programme is specifically required), and the full computing speed is available without the necessity for arranging the orders in any special way. The time required for addition, subtraction or for most of the organising operations, is 234 microseconds. Multiplication and division are autonomous functions and can be carried out simultaneously with other operations.

The second system represented on the Ferranti stand (" Pegasus " converter data processing) is designed for the many internal transactions which are handled by punched card systems in a manufacturing concern. Generally in such transactions there are files to be maintained involving tens of thousands of parts in various stages of manufacture. Most of this information is in numerical form, and the operations to be performed involve rather more calculation and less administrative routine than in the class of work for which " Perseus " was designed. Examples are the process of computing requirements for minor assemblies and detailed parts from sales forecasts of major assemblies, computing a machine-loading plan for a general machine shop, up-dating an inventory file, or carrying out a complicated sales analysis complete with comparisons with previous periods. In this field it is often necessary to be able to correlate facts arising in different parts of the business, and it is a great advantage to have a computer with a large main store which can also handle magnetic tapes. Print-out facilities with speed and flexibility are required, able to handle information which is mainly numeric but partly alphabetic.

Economical handling of this numerical information is the aim of the " Pegasus " converter system, which combines large storage with fast computation and built-in equipment for rapid input and output conversion. It has a capacity for 7000 words of thirty-nine binary digits and is equipped with four magnetic tape mechanisms. There are built-in facilities for converting punched card images on magnetic tape into binary words, and vice versa, and facilities for the transfer of information between the main and computing stores. " Pegasus " can handle variable length magnetic tape records. Parity checks are built-in in all parts of the system and there are built-in magnetic tape checks. The output is obtained by off-line printing on a 150 line-per-minute alpha-numeric printer. Provision is made for the selective off-line printing of specific items. Off-line conversion can be carried out from card to tape and tape to card.

Twenty-two " Pegasus " computers are now in operation, mainly in universities and in aircraft and other engineering industries.

The " Pegasus " direct data processing system is intended for commercial work in industry, such as pay-roll compilation, where the computer processes information at card-reading speeds. Hollerith, I.B.M. and Powers-Samas cards for direct input to and output from the computer, and the Powers-Samas off-line magnetic tape " Samastronic " printer can also be used. There are built-in facilities for converting punched card fields into binary words and vice versa. Up to sixteen magnetic tape units can be used.

The " Mercury " computer is claimed to be the largest and fastest digital computer made in Europe for large-scale planning, and technical calculations of the kind that arise in continuous multi-product processes, such as oil refining. " Mercury " computers have been ordered by seven nuclear research organisations, for work in physics and engineering. They are now being produced at the rate of one every two months.

With their built-in, floating-point arithmetic facilities " Mercury " computers are specially suitable for linear programming calculations. They have a large storage capacity, with 1024 immediately accessible words and 16,384 words stored on magnetic drums. A magnetic tape system is being developed and auxiliary equipment is available for punched card and line printing. Parity checks are included throughout the system.

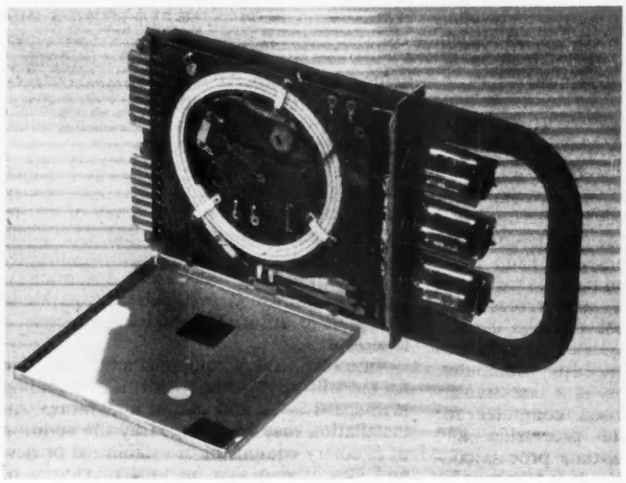


Fig. 2—A single-word nickel delay-line package of the " Perseus " computer. Access to the information stored in these delay lines is immediate—Ferranti

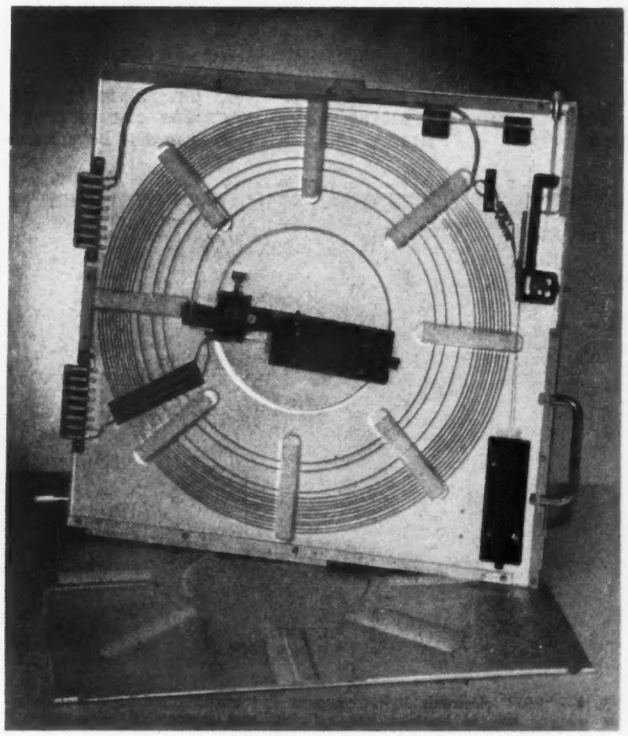


Fig. 3—A sixteen-word delay-line package of the " Perseus " computer. The average access time to these lines is two milliseconds—Ferranti

Some of the exhibits illustrate interesting development work on digital computers applied to machine tool control, carried out recently by Ferranti, Ltd. It includes the development of digital differential analysers with increased versatility.

Digital differential analysers are designed to generate the contour paths for the Ferranti control system in conjunction with a general-purpose computer. In the simpler analysers now available, the differential digital output may control directly a digital plotting table for two-dimensional graphical display with high accuracy. Thus it is possible to reduce considerably the print-out time of a general-purpose computer and effect cost savings.

Another interesting innovation is the Ferranti digital plotting table which has been designed to plot at high speed, two-dimensional digital information, in conjunction with a digital analyser attachment. It can also be operated from a suitable input as an automatic drafting machine, and in this instance use can be made of the Ferranti computer service established in Edinburgh.*

Digital differential analysers have been used by Ferranti, Ltd., over the past seven years for their computer-controlled machine tools, but the techniques can be used to solve any continuous computing process. For example, applications are to be found in simulators, computers for process control, and accurate multipliers and axis transformers for analogue differential analysers. Essentially, these computers carry out a simple integration procedure at high speed. The size of the integration steps determine the computing speed and accuracy. Multi-level overflow techniques have now been developed with a thirty-fold increase in speed without sacrificing the computing accuracy. Although these operations could be programmed on a general-purpose computer, the computing times involved are so long as

* The company also has a computer service at the London Computer Centre, 21, Portland Place, London, W.1.

to be uneconomic, due to differences in the nature and layout of the logical, computing and storage elements. In addition, the one-to-one correspondence between terms of the equation and integrator units gives the engineer or mathematician an easier understanding of its contents.

The drive is by M-type transmission motors, which are transistor controlled and fed with pulsed information. Each pulse (positive or negative) causes a pen displacement in the appropriate sense of one digital unit. The machine is designed on kinematic principles to reduce drive friction, and the carriage weight is controlled to give the best practicable dynamic performance. Maximum traverse velocity is 60in per minute with a digit size of 0·005in and overall accuracy is better than 1 in 1000. Some flexibility is permissible both on machine size and on digit size to suit specific requirements.

Standard integrator packages have now been designed by Ferranti, Ltd., to meet the demand for a real time simulator with a better accuracy than their present analogue versions. The integrators, which use serial binary arithmetic, have been arranged to operate in parallel and are connected up in a similar manner to analogue differential analysers. The accuracy can be varied depending on requirements. A 5 c/s bandwidth, for example, will give an accuracy of 0·1 per cent, which compares favourably with analogue equipment. Digital-to-analogue converters enable the packages to be integrated with analogue computers and control systems. If the operating speed is not an important factor, the integrators can be time-shared to reduce costs.

The packages are built up of transistorised logical elements, phasing electromagnetic delay lines and nickel delay line stores. The clock frequency is ½ Mc/s and the word length is chosen to give the required accuracy. Marginal checking facilities are available for testing. The logical rules and loading restrictions on the cards are simple and easy to understand and the unit assembly of the individual components enables customers to assemble their own computers if they so desire. In addition, wiring sheets with the engineers' logic combined on the same sheet are available to keep the logic-to-wiring transfer work, with its inevitable mistakes to a minimum.

For handling special-purpose three dimensional machining problems the company has prepared a collection of programmes. For example, turbine blades, compressor blades, water runners and ships propellers can be produced on a controlled machine tool without the use of expensive masters. Using a three-dimensionally-controlled shaping machine a 6in blade can be produced in four minutes to an accuracy of ±0·001in with a computation cost of less than £30. Again, a three-blade ship propeller of 4ft diameter can be completely machined in fifteen hours. No drawings are required as the information to the computer can be taken direct from the hydrodynamicist's figures. The computation costs are of the order of £60 which is only incurred once for each set of propellers. From hydrodynamicists' figures to a completed ship's propeller will therefore take less than three days compared to anything up to three months by existing methods. The cost to produce templates and cams can also be substantially reduced. Using a medium-sized machine tool, intricate template profiles can be machined at a cost of approximately 6s. per foot run compared to conventional costs which can be as high as £2 per foot run.

Fig. 4—" 950 " electronic digital computer is " transistorised " and is intended for general use in mathematical, scientific and engineering computation—Metropolitan-Vickers

Metropolitan-Vickers Electrical Company, Ltd.

Two new computers made by Metropolitan-Vickers Electrical Company, Ltd., Trafford Park, Manchester, 11, are represented. First there is a scale model of the " Metrovick 1010 " computer. This is a fast transistorised computer for data processing and real-time process control ; it is also capable of solving complex scientific and engineering problems. A characteristic of this computer is the data scanner, which transfers information between the magnetic-core store and all ancillary equipment. Secondly, there is the " Metrovick 950 " electronic digital computer, which is an inexpensive transistorised general-purpose computer designed for use in solving a variety of mathematical, scientific and engineering problems. A " 960 " paper tape reader and a centralised monitoring and control system, including analogue-to-digital conversion are also being exhibited.

The Metrovick " 950 " computer (Fig. 4) is designed to meet the demand for a reliable medium-speed computer within the means of small firms, universities and technical colleges. It consists of five main parts—input equipment, store, arithmetical circuits, output equipment and control unit. Information is fed into the machine by means of a photo-electric punched-paper-tape reader, the paper tape having a five-hole code ; the instructions and data are stored on an aluminium drum coated with a magnetic oxide, on which information is recorded in the form of magnetised spots on circumferential tracks. The arithmetical and control circuits incorporate junction transistors, which means that size and power consumption are appreciably reduced. Output is by means of a five-hole punched paper tape and printed page, the latter being very convenient during development of a computer programme. The control unit co-ordinates the operation of the whole machine.

The thirty-two instructions obeyed by the " 950 " computer have been chosen explicitly to make programming easy. The machine is a " 1+1 address " system, that is to say, in each instruction two addresses in the drum store are mentioned, the operand and the next instruction. With the optimum timing the machine will obey between 150–200 instructions per second. The optimum timing principle is often held to be a difficulty in programming, but the method used with the " 950 " of coding and optimising simultaneously is designed to be simple.

The " Metrovick 1010 " computer is designed for data processing and real-time process control, and is capable of solving complex scientific and engineering problems. It is a fast transistorised computer with parallel arithmetic circuits, magnetic-core working store and various ancillary apparatus.

The fast arithmetical and control unit operates in the parallel mode, and carries out typical data-processing programmes at a speed of some 50,000 simple address instructions during every second of operation. Word length is 44 digits and contains two 22-digit instructions. A " *B* " line has 13 digits and is capable of performing limited operations. The very flexible instruction code provides a wide range of instructions ; both fixed-point and floating-point calculations can be performed.

The immediate-access store holds either 2048 or 4096 words, each of forty-four binary digits in a three-dimensional array of ferrite cores. Each word may contain two computer instructions, a 13-digit decimal number, or a group of coded alphabetical characters. Auxiliary storage is provided by two kinds of magnetic drum store and by a magnetic tape store.

Various ancillary equipments are available for use with the " Metrovick 1010," including high-speed input and output apparatus. An installation may be enlarged by the addition of ancillary equipment of established or new and improved design up to a maximum of thirty-two units. Each unit is allowed to operate at its optimum speed by using a small buffer store to isolate it from the computer.

An interesting innovation in the " Metrovick 1010 " is the data scanner, which transfers information between the magnetic-core store and all ancillary equipment. The data scanner interlaces the transfers automatically word by word, with the execution of computer instructions, and it can maintain simultaneous transfers of blocks of data to or from all ancillary apparatus. This system allows relatively slow peripheral equipment to be connected " on-line " to a very fast computer, without delaying computation by printing out, &c.

The instruction code provides facilities for the operation in parallel of a number of programmes having compatible storage requirements. Programmes may be interrupted in order to execute another programme of high priority, as for instance, to carry out emergency operations when alarm conditions occur in a computer-monitored process plant.

The accuracy of all instructions and information is checked as they are withdrawn from the working store and at every stage in their passage through the computer. Data which has been transcribed on to magnetic tapes for future reference is checked automatically after recording.

The " 960 " tape reader is a self-contained unit (Fig. 5) which has been designed to read standard five-channel teleprinter tape at a

maximum speed of 250 characters per second. It can be used for input of instructions and data to digital computers, and for

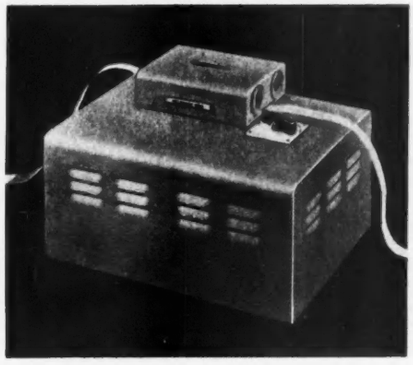


Fig. 5—The "Metrovick 960" paper tape reader is designed to read five-character teleprinter tape at a maximum speed of 250 characters per second —Metropolitan-Vickers

programme control of process plant and machinery where a high rate of control is required. The tape is read character by character under the control of the computer or other equipment, and can stop on any character at all speeds up to the maximum. The reader anticipates the demand for information by reading one character in advance and storing it in immediate readiness. A new character is read at the same time as the computer or control apparatus is acting upon the previous one. Transistors have been used for all parts of the equipment, including photo-electric cells and associated amplifiers, power amplifiers for the actuating coil and the stabilised power unit.

An exhibit of considerable general interest is the company's centralised monitoring and control system for large industrial installations. The main components of the Metropolitan-Vickers system for central monitoring and control are primary measuring elements, static analogue-to-digital converters, digital data transmission, and display. The exhibit represents an oil storage and distribution installation. The transmission of the values of temperature, pressure and level demonstrates the functions of the components of the Metropolitan-Vickers system. These values, measured at the oil storage tank, are transmitted and displayed on decimal indicators at the control room. For low-power consumption reliability and compactness, transistors are employed throughout the electronic equipment.

(*To be continued*)

Electronic Digital Computer, "ACE"

The digital computer known as "ACE" (Automatic Computing Engine), described here, is now in service at the National Physical Laboratory, Teddington. It has about six times the capacity of its forerunner, the pilot model, which was completed in 1951. *"ACE" itself is a serial computer in which the numbers and instructions have forty-eight binary digits. The main store has twenty-four mercury delay lines (each of thirty-two words), with a major cyclic time of* 1024 *microseconds. Mercury delay lines of one, two and four-word capacity provide rapid access storage. Four magnetic drums make up the backing store which has a capacity of* 32,768 *words.*

A NEW electronic digital computer known as "ACE" (Electronic Computing Engine), which is believed to be unsurpassed in speed and capacity, is in operation at the National Physical Laboratory, Teddington, Middlesex. It was built by the Control Mechanisms and Electronics Division of the N.P.L., in collaboration with the Mathematics Division, and it will be used mainly for work on the general methods of carrying out high speed computations, typical examples of which are design calculations for high-speed aircraft, guided missiles and nuclear reactors.

It may be recalled that "ACE" is the product of research which began at the National Physical Laboratory in 1945, when the late Dr. A. M. Turing joined the staff of the Mathematics Division, where he produced, with his collaborators, a logical design for a computer intended to carry some of the load of numerical calculation. He called it the Automatic Computing Engine or "ACE." In 1947 a special section, now the Control Mechanisms and Electronics Division—was set up to carry out the development of the machine. Because of the anticipated difficulty of building so large and complex a machine in one step, it was decided to make first a pilot model of much smaller power and capacity.

Accordingly, a pilot-model "ACE," only one-sixth of the size of the present machine, was built to provide experience of the engineering problems which would arise in the full-scale machine. It was completed in 1951 and during its five-year life at N.P.L. (before it was presented to the Science Museum in 1956), it did a considerable amount of work, including extensive calculations to discover the cause of failure in the early "Comet." It was also the pilot model which led to the commercial production of the English Electric "DEUCE" computer. Moreover, it provided the team of mathematicians, logical designers, electronic engineers and mechanical engineers with the essential experience to undertake the more ambitious full-scale "ACE" project.

Mercury delay lines and magnetic drums (the working and backing stores respectively) are used for the storage of numerical data and instruction sequences, and both punched card and magnetic tape equipment are provided for input and output.

"ACE" is a serial computer in which numbers and instructions have forty-eight binary digits (equivalent to fourteen decimal digits). The digit rate is 1,500,000 per second and, therefore, its word time or minor cycle is 32 microseconds. The main working store consists of twenty-four mercury delay lines, each containing thirty-two words, circulating in a major cycle of 1024 microseconds. Rapid access storage is obtained by using mercury delay lines of one, two and four words capacity. The backing store consists of four magnetic drums containing a total of 32,768 words and rotating at 12,000 r.p.m.

The "ACE" instruction specifies a three-address operation of the form "*A* function *B* to *D*," where *A* and *B* are the store addresses of the operands and *D* is the store address to which the result of the operation is to be sent. Instructions also specify a further store address *N*, from which the next instruction is to be extracted. The time needed to execute this operation (for single length numbers) is 32 microseconds and since each operation may be followed immediately by another, a maximum rate of operation of 30,000 per second is possible.

The instruction word uses forty-seven of the forty-eight digits divided into groups, as follows :

Groups of Digits Used in Instruction Word of "ACE"

Group ...	*W*	*A*	*B*	*F*	*D*	*St*	*N*	*J*	*T*	*Ch*
No. of digits	5	6	6	6	6	1	5	5	5	2

Wait number (*W*) ... The minor cycle with which the operation will start

Source *A* ... ... Address of operand *A*

Source *B* ... ... Address of operand *B*

Function (*F*) ... ... Specifies one of 64 functions, selected from the following main function groups :

(0) Logical
(1) Shift
(2) Add, subtract
(3) Clear and add, subtract
(4) Instruction modify
(5) Multiply, divide, standardise, input and output operations
(6) Multiply by small integers
(7) Add, subtract and discriminate on result

Destination (*D*) ... The address to which result is sent. In addition to store addresses there are special destinations such as those for discrimination on the result (i.e. conditional transfer of control)

Stop (*St*) ... ... Allows computer to be stopped on selected instructions (used mainly during programme testing)

Next instruction source (*N*) Store address from which next instruction will come, which may be any of the 24 long or some of the shorter delay lines

Auxiliary timing (*J*)... Used for counting prior to a transfer o control

Timing number (*T*) ... The minor cycle from which the next instruction is extracted

Characteristic (*Ch*) ... Determines the length of the operation which may be :

(*a*) Single ... ... Transfer occurs during minor cycle *W* only

(*b*) Double ... ... Transfer occupies minor cycles *W* and *W*+1

(*c*) Quadruple ... Transfer occupies minor cycles *W*, *W*+1, *W*+2 and *W*+3

(*d*) Long ... ... Transfer starts at *W* and continues until *T*, inclusive

(*b*), (*c*) and (*d*) are useful for operations concerned with multiple length numbers.

The drawing on page 838 shows a block diagram of "ACE." Full lines represent channels carrying signals at a rate of 1,500,000 pulses per second. Dashed lines are multiple channels in parallel carrying signals which change at about minor cycle rate (31,250 per second), and these channels operate gates and triggers.

The outputs from the delay lines are gated to the Source *A*, Source *B* and "Instruction" highways. The inputs come from the function unit via the "Destination" highway. The function unit is what would usually be called the arithmetic unit but it carries out many non-arithmetic operations as well.

It will be seen that the drum store, the multiplier and the divider are independent units. They are put into operation by the appropriate instructions and then work independently until they have completed their operation. This feature provides parallelism of operation, since a multiplication, division, drum transfer and a series of ordinary operations could be in progress at the same time.

The three-address operation of the machine allows the multiplier and multiplicand to be selected and the multiplication process to be initiated by a single instruction. The product is formed in fourteen minor cycles, that is, 430 microseconds. Division is similarly specified and the quotient (rounded or unrounded) is formed in about 1·5 milliseconds. The divider also contains an auto-

matic standardising process for use in floating-point arithmetic operations.

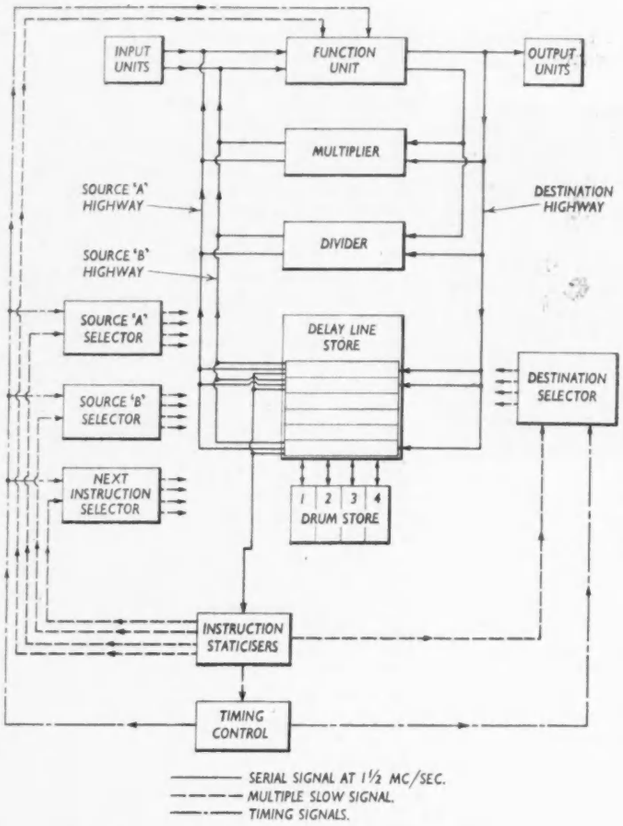
Speed of "Ace"

It is not easy to assess the speed of a machine from the times taken by the elementary arithmetic and logical operations. This is particularly true of any machine with high-speed stores of less than about 8000 words, on which many problems will demand the use of the backing-up store. The times taken for a few basic computations probably give as accurate a picture of the overall speed as can be obtained without a detailed study.

(1) The zeros of a sixteenth degree polynomial may be obtained in an average time of fifteen seconds. Because of the long word length (forty-eight digits), accurate roots even of very ill-conditioned polynomials of this degree will be obtained. Polynomials of degrees up to about 250 may be found without using the drum store, though no sharp discontinuity in speed results from using the drum on this problem.

(2) A set of simultaneous equations of order thirty can be solved in about five seconds. Sets containing no zero coefficients of orders up to 170 may be solved, the time taken varying approximately as the cube of the order but diminishing as n becomes large.

(3) The solution of Poisson's equation, $\nabla^2 V = 4\pi\rho$ on a square with 400 mesh points, may be obtained in about seventy-five seconds. This time is for the direct solution of the finite difference equations and will give values correct to at least ten decimals. After solving one such problem, solutions corresponding to different distributions of ρ may be obtained in about fifteen to twenty seconds each.



Block schematic diagram of electronic digital computer "ACE"

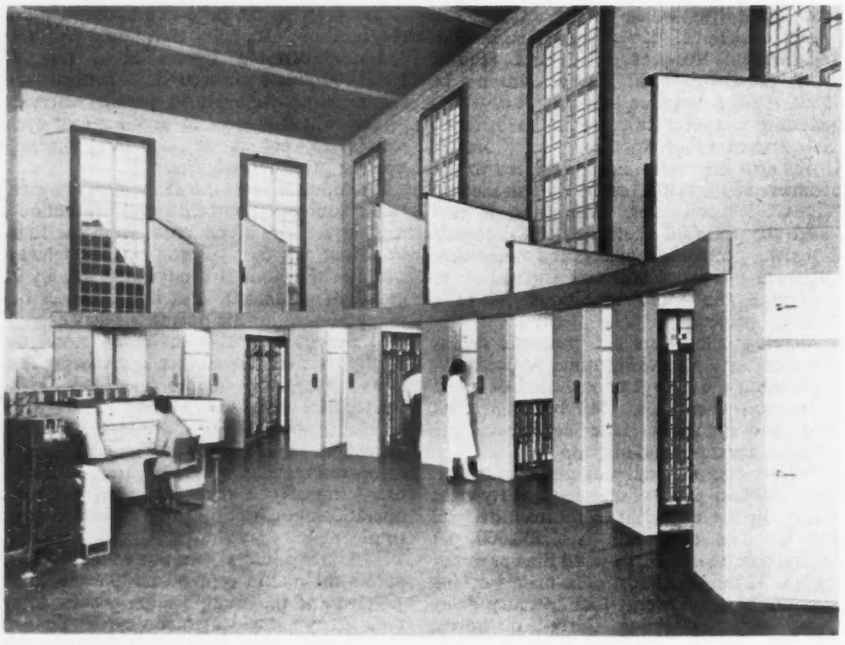
General Arrangement of "Ace"

The magnetic drum store has a total capacity of 1024 long delay lines, that is about 1,500,000 digits. There are four drums each having 256 tracks, each track storing the contents of one delay line. Each drum has sixteen read heads and sixteen write heads, the 256 tracks being obtained by moving the heads as one unit into one of sixteen discrete positions. Each drum is 6·75in long by 5in diameter, allowing a linear digit packing of 100 per inch. A hysteresis motor drives each drum; it runs synchronously at 12,000 r.p.m. and is phase-corrected so as to rotate exactly once in five major cycles of the machine.

Punched card and magnetic tape equipment are available for input and output. The installation will initially consist of two machines: one, a broadside card reader, running at 450 cards per minute, and the other a broadside card punch running at 100 cards per minute. To read or punch eighty columns of a card, the computer has an eighty-digit input dynamiciser and an eighty-digit output staticiser.

"ACE" is equipped with a control desk which can be seen in the photograph reproduced below. Extensive marginal checking facilities are built-in and the desk has 160 keys and 300 signal lamps in addition to aural checks and visual displays of the computation. Most computations, however, are carried out simply by pushing the "Initial Input" key which causes the punched cards to be read, whereupon the operating instructions to "ACE" are initiated.

The computer itself is housed in ten cabinets, each of which is fitted with a rising door to give immediate access to any of the twenty-four chassis in the cabinet. There are about 6000 miniature valves, the heater load being only 20kW, while the total heat dissipation is 50kW. Each cabinet is cooled by a simple closed circuit air ventilation system with a water cooled heat exchanger embodying an automobile radiator. Of the total cost of the "ACE" installation (about £250,000), less than 1 per cent is attributable to the cooling system.



The electronic digital computer "ACE" at the National Physical Laboratory is approximately six times as large as the pilot model which preceded it. Punched card and magnetic tape are used for input and output. The working store (mercury delay lines) contains 800 words and the racking store (four magnetic drums) contains 32,768 words

Technical Reports

Research Report No. 4: The Specific Surface of Concrete Aggregates and its Relation to the Workability of Concrete. By B. W. Shacklock and W. R. Walker.

Research Report No. 5: An Investigation of Transmission Length in Pretensioned Concrete. By G. Base.

The Design of Right Concrete Slab Bridges for Abnormal Loading. By R. E. Rowe.

All these reports are published by the Cement and Concrete Association, 52, Grosvenor Gardens, London, S.W.1, and are available free. Each one relates to work carried out at the Association's research centre. Report No. 4 gives a background to understanding the relation between workability of a concrete and the grading of its aggregates, which is of importance in interpreting the relevant British Standard on aggregates, B.S. 882 : 1954. Report No. 5, the "bond" or transmission length needed to transfer fully the load from steel to concrete in pretensioned concrete, is investigated, for conditions such as are met with in normal factory production or on the building site.

The Rowe report is a further step in the Association's work on the abnormal loading of non-skew bridges. It was previously shown that structural behaviour was modified by the shape of the bridge deck. By considering only slab bridges of standard widths, the problem has been simplified, so that maximum longitudinal and transverse moments can be plotted in terms of the moments due to the Ministry of Transport's standard loading for each width of bridge.

Natural Gas in Pakistan

By V. S. SWAMINATHAN, M.A., M.Sc.(Lond).

During the past decade Pakistan has intensified the search for fossil fuels (coal, oil and natural gas) and atomic minerals. In 1956 nearly 11,000,000 barrels of petroleum products were imported, compared with a domestic output from West Pakistan of just over 2,000,000 barrels of crude oil. Natural gas, discovered at Sui in Baluchistan and Sylhet in East Pakistan, should mitigate this deficiency in domestic energy supplies: progress made in the use of Sui gas in West Pakistan and proposals for the utilisation of Sylhet gas are described here.

IN March, 1953, an American consultant was invited by the Pakistan Petroleum Company (P.P.L.), a subsidiary of the Burmah Oil Company, to report on the Sui natural gas discovery in Baluchistan, and its distribution. His report, calling for a 16in pipeline descending the Sui range, by-passing the Indus valley and linking the gasfield to Karachi, a distance of nearly 348 miles, was accepted. The map reproduced herewith shows the course of the pipeline. It was reckoned that at the start of the pipeline's operation existing industrial installations —mainly electrical, textile and cement establishments—would absorb about 37,000,000 cubic feet of gas daily. An eventual service of treble this amount was envisaged, with a developed capacity, following the completion of two booster stations of 110 million cubic feet a day, and this is the capacity of the pipeline which was commissioned late in 1955. The saving to the Pakistan Government in foreign exchange in the initial phase of operation was computed at around Rs. 25,000,000.

The actual construction period of the Sui-Karachi pipeline was 168 days, which, in the light of difficult terrain and climatic conditions, was an excellent achievement. It was built in two spreads, travelling north

Map of West Pakistan showing the Sui-Karachi and Sui-Multan pipelines

and south, from a point 135 miles from the gasfield. Starting at Sui the line descends 750ft to the desert on to the irrigated lands at the Sukkur crossing of the Indus River. Skirting the Khairpur Desert and traversing the rich cotton and wheat areas of the Hawabshah and Hyderabad districts of Sind, the line re-crossed the Indus at Kotri. Between Kotri and Karachi the terrain is rock desert. Communication between the spreads was by radio to Karachi, each spread having a station. Rapid travelling along the line was accomplished by two "Dove" aircraft, and a helicopter was used for survey work.

The contract for laying the Sui-Karachi pipeline was awarded by the Sui Gas Transmission Company (S.G.T.C.) to D. and C. and William Press and Son, Ltd., who entered on a joint venture with the Morrison-Knudsen Corporation of the United States to form the Pakistan Constructors Company to complete the work. Despite formidable difficulties the contract schedule was bettered by nearly three weeks, thus setting up a record outside the United States for the completion of a gas pipeline of this size. Fabrication commenced in September, 1954, and bends, where required, were effected by a stretch bending machine. The rate of progress in the laying of the pipeline was conditioned by the nature of the terrain traversed and included major river crossings, a dozen canal crossings of over 250ft and forty-five smaller ones. The overall laying rate was 2·08 miles a day, but on occasions a length of over 3 miles was welded, primed, enamelled, wrapped and ditched and backfilled.

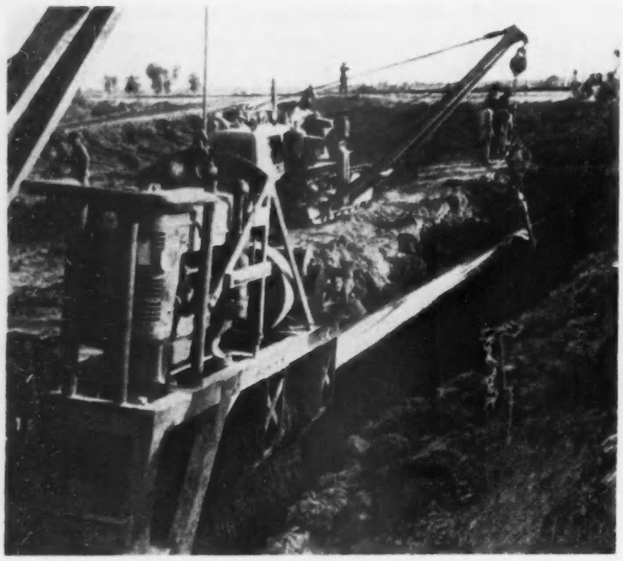
The pipe is 16in O.D. seamless steel, high-tensile material, to A.P.I. specification 5LX by 46, in three thicknesses—0·438in, 0·312in, and 0·250in, depending on the location—and was ditched throughout with 3ft 6in cover, except at valve emplacements and river and canal crossings. The 0·438in thickness was used at the barrage crossings only. Except at barrage, river and canal crossings, the pipe was coal tar enamel-coated with a "Fibreglass" inner wrap, and, depending on the location, with a thermo-glass tar impregnated or Kraft paper outer wrapping. At barrage and canal crossings, a wrapping of Lassoproof p.v.c. tape, with a finishing coat of aluminium paint, was applied. The pipeline is cathodically protected.

Two techniques were followed to take the line across at river and canal crossings. Where the distance was short the line was laid on the bottom and the pipe weighted down with concrete saddles. At wider crossings, it was carried on steel pile supports, broad flanged beams, at 50ft intervals, with walkway shades provided over the pipe. Rail, as illustrated, and road crossings were effected by boring and sleeving with a 20in O.D. steel pipe, primed and given one hot flood coating of coal tar enamel, retaining straps and Williamson seals being fitted at sleeve-ends. At the Lloyd barrage crossing at Sukkur, the pipeline, protected by a casing, was threaded through the concrete piers, which entailed cutting the latter. In all, sixty 10ft thick and seven 30ft thick piers were pierced for a 20in casing, which was grouted in. This work was sub-contracted to the Cementation Company, Ltd. The pipe itself was then threaded through the casing and supported on slides. At the Kotri barrage crossing, the pipe was carried within a steel-box framework supported from the cut-water concrete piers of the barrage.

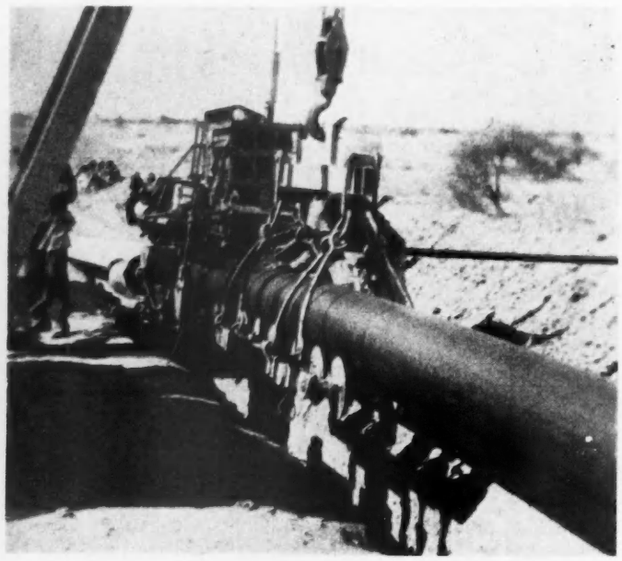
The Sui-Karachi line traverses dry, in part desert, terrain, for nearly 180 miles, of which the first twenty run from Sui and the last ninety-six into Karachi. The rest lies in patches, with wet irrigated stretches, one of which is illustrated, occupying the remainder of the route of approximately 170 miles. Rock was prevalent over a fifth of the length, calling for considerable blasting and rock drilling work, as seen in the illustration. Nearly thirty main 12in valves, including automatic shut-off valves at each of the two barrage crossings, and 140 smaller ancillary valves of 1·5in, 4in, 6in and 8·5in sizes, and a considerable number of necessary specials—tees, bends, transition pieces or reducers, &c.—were laid along the route. As the pipe was welded into sections, and prior to tying-in, cleaning, coating and wrapping, go-devils were sent through by compressed air to remove dirt. The sections were then air-tested at 100 lb per square inch, and examined for leaks at each weld by coating with primer solution. The final pressure test was made hydraulically at 1285 lb per square inch on the 0·312in and 0·438in thick pipe, and at 1020 lb per square inch on the 0·250in thick pipe.

This pipeline called for 43,836 long tons of pipe, which was supplied by Stewarts and Lloyds, Ltd. The Motherwell Bridge Contracting and Trading Company, Ltd., was responsible for constructing the collecting lines, consisting of 8 miles of 16in, 4 miles of 6in, and 3 miles of 4in pipe, from the gas wells to the purification plant at Sui. It also provided the supply lines, all wrapped and buried thus :—At Rohri, 3·5 miles of 6in pipe ; at Khairpur, 5 miles of 6in ; at Hyderabad, 5·5 miles of 10in; and at Karachi, 24 miles of 16in, together with several miles of supply lines in various smaller sizes. In addition, the company constructed all houses and industrial buildings at the Karachi terminal, and erected the intermediate control stations. Local climatic conditions were exceptionally severe, with mean maximum and minimum temperatures of 108 deg. and 82 deg. Fah., respectively ; therefore, a camp was provided for each spread, the cabin made of aluminium insulated with glass wool and air conditioned. Each camp was fully serviced as regards electricity, water and drainage.

The producer of natural gas at Sui is Pakistan Petroleum, Ltd., owned 70 per cent by the Burmah Oil Company (B.O.C.), and 30 per cent by the Pakistan Government. The Sui Gas Transmission Company, jointly promoted by the B.O.C. and the Pakistan Industrial Development Corporation, buys gas from Pakistan Petroleum, Ltd. Toward the completion of this major power project the World Bank loaned £5,000,000 to Pakistan Petroleum, Ltd., and under a twenty-year contract the B.O.C. (Pakistan Trading) Ltd., will act as managing agents for Sui Gas Transmission Company, Ltd. Meanwhile, six wells have been drilled at Sui, establishing that the reservoir is wider and longer than initially envisaged. Lastly, a gas purification plant was completed. The Karachi Gas Company was incorporated in October, 1955, with an authorised capital of Rs. 50,000,000, to undertake the distribution of Sui gas to factories and dwellings. Its main job is to extend the distribution of gas as widely as possible for industrial and domestic consumers. This new undertaking has acquired, from the Sui Gas Transmission Company, pipelines to Landhi (a major industrial centre), together with ancillary equipment. Close on 30,000,000 cubic feet of gas a day is now being used daily by industrial consumers. The Pakistan Controller of Capital Issues has



Pipeline at railway crossing



A string of the Sui-Multan pipelines being coated and wrapped

accorded consent to an initial issue of shares thus : Rs. 15,000,000, out of which the Pakistan Industrial Development Corporation and Industrial Management have subscribed Rs. 5,000,000 each. The balance has been offered for public subscription.

Following the decision to pipe Sui gas to Karachi, for industrial and domestic uses, the project to install a gas purification plant at Sui to remove the acid and moisture contents before putting it into the pipeline was taken up in June, 1954. Analysis of the gas taken from the wells showed that the hydrogen sulphide and mercaptan contents were fairly constant over the entire field, but carbon dioxide varied from 4 to 8 per cent. The mercaptan content was deemed acceptable for industrial and domestic purposes, and an installation for the removal of hydrogen sulphide, carbon dioxide and moisture only was proposed. Other considerations in the development and design of the plant were the probability of subsequent expansion and the necessity for providing standby capacity due to the corrosive nature of certain aspects of the purification process, and the remoteness of Sui from sources of supplies of engineering equipment and materials. Furthermore, limitations were imposed on the maximum size and weight of individual plant units by the transport difficulties between Karachi and Sui, entailing a rail journey of 300 miles, followed by some 70 miles of road haul over rough desert country.

A purification plant capable of handling 74,000,000 cubic feet of gas per day was envisaged. It was to consist of two 37,000,000 cubic feet per day sections, one of which to be kept as standby. As the sale of gas increases further units are to be added to satisfy demands and to ensure standby capacity at all times. In mid-1954 demand was anticipated to grow eventually to 120 million cubic feet a day.

The plant is located on a barren rocky plain at the foot of the Bugti Hills, 350 miles north-east of Karachi. The nearest point on the broad gauge railway is 70 miles to the west at Temple Dera, while Kashmor, 40 miles to the south-east of Sui, is served by a narrow gauge railway branch line from Jacobabad. Roads have been constructed from Temple Dera and Kashmor to Sui, and these provide the only access to the site. Climatic conditions at Sui are rather severe, as will be seen from the following particulars, which indicate the worst conditions :—

Shade temperature, deg. Fah., max.	120
Shade temperature, deg. Fah., min.	30
Humidity at 70 deg. Fah., per cent	100
Humidity at 95 deg. Fah., per cent	70
Humidity at 105 deg. Fah., per cent	50
Humidity at 130 deg. Fah., per cent	5
Altitude above sea level, feet	25

The atmosphere is saliniferous, corrosive and dusty.

The well head gas pressure is of the order of 1800 lb per square inch gauge, and the gas is delivered to the purification plant by a field collection system. The purified gas has to be delivered to the pipeline at a pressure of 1070 lb per square inch gauge, the gas pressure within the plant being governed by a controller on the inlet side, set to give the requisite pressure at the main pipeline. The installation therefore operates on a gas pressure of around 1100 lb per square inch gauge. The process used for removing the acid constituents is the well-known mono-ethanolamine (M.E.A.) one incorporating continuous reactivation of the M.E.A. solution followed by dehydration. The gas is transferred from the collection system header to the plant by a 12in main in which the main pressure controller is located. This inlet main is then split to feed the two 37,000,000 cubic feet sections, the flow through each section being as follows :—The gas is passed through a gas cooler to a scrubber which removes the hydrocarbon condensate. The gas then passes to the M.E.A. contactor tower where the acid gases are absorbed by the solution. It later passes on to a further scrubber for removing M.E.A. mist and thence to the dehydration plant, consisting of two units each capable of taking 74,000,000 cubic feet per day. One dehydrator is on-stream while the other is being regenerated. The purified gas is eventually passed into the main pipeline.

Rock ditch to take pipeline

The rich M.E.A. solution passes from the base of the M.E.A. contactor tower at reduced pressure to a flash tank and from there via heat exchangers to the top of the M.E.A. reactivator tower where the acid gases previously absorbed are stripped from the solution. After passing through a reflex condenser and accumulator, to remove the steam carry-over, the acid gases are passed to a stack for dispersal to atmosphere. The lean M.E.A. solution from the base of the reactivator is passed via the exchangers and coolers to the surge tank. It is then pumped to the top of the contactor tower by means of steam turbine-driven centrifugal pumps. The two distinct plant sections are so designed and inter-connected that there is complete interchangeability of units. The plant sections are arranged on either side of a central overhead pipe rack which continues to the boiler plant area. The very large pressure drop required in the gas fuel supply for the boilers is utilised for driving a two-stage recompressor for re-compressing low-pressure hydrocarbon vapours which are flashed off in various units. The recompressed vapours are then re-admitted to the inlet gas stream.

The relief valves on all gas-containing units are connected to a hydrocarbon flare system. In addition, a manually operated connection to flare is provided on the down-stream side of the main pressure controller. The plant is protected from excessive well-head pressure by a relief valve, connected to flare, on the collection system header. A sour gas by-pass is provided around the plant for commissioning the boilers and for boosting the pressure in the main pipeline

for testing purposes. A high-pressure shut-down is incorporated with the main pressure controller on the inlet side of the plant to shut off the gas supply automatically should a blow-out occur. A check valve is also provided immediately downstream of the dehydration units to prevent a reversal of gas flow from the pipeline. Spare branches with blanked off valves are installed on the collection system header and another header similarly equipped is installed on the downstream side of the plant, so that future extensions can be connected without having to shut down the plant. The main pipeline is connected to this latter header.

Utilities on this undertaking were given careful consideration. Water is pumped a distance of 38 miles to Sui from the Indus River and the need for its conservation is great. Difficult up-country transportation and the short time permitted for erection limited the choice of boiler plant, and the remoteness of Sui from large electricity undertakings entailed it being self-supporting as far as power supplies are concerned, and, in addition, the power had to be provided for the needs of the residential area, administrative offices, area workshops, and so on.

The raw water is allowed to settle in tanks near the Indus River and stored in two 10,000-barrel tanks at the purification plant. Water required for the plant and for domestic purposes in Sui is passed through pressure sand filters and water for the plant is treated by base exchange softeners. The boiler plant consists of three 45,000 lb per hour Babcock and Wilcox FF15 No. 36 integral furnace boilers with a working pressure of 400 lb per square inch gauge and a steam temperature of 580 deg. Fah. A de-aerator heater is provided, together with feed water storage, chemical dosing pumps, &c. It is proposed to return approximately 95 per cent of the condensate so that the actual softened water make-up will be small. Two 200kW back pressure Westinghouse turbo alternator sets are provided—one operating, the other stand-by. They are intended mainly for supplying the electricity demands of the Sui area. Both the boiler and generating plants are arranged with a view to further extension, and in the event of the purification plants being out of commission they can operate separately as a generating station.

The plant cooling arrangements have been designed with special regard to conserving water and so air blast coolers are used in certain parts of the plant. The cooling towers are of Hudson induced draught design, the air coolers are of Solo-aire pattern and the water cooling towers are of Combine-aire pattern. Most of the prime movers in the plant are back pressure turbines which exhaust at 50 lb per square inch into the process steam mains. A Solo-aire cooler is provided for condensing steam surplus to actual requirements. The Sui gas purification plant is fully controlled and instrumented and a control room is centrally located within the plant area. Instrument air is provided by an electrically-driven air compressor, the compressed air being dehydrated before being passed to service. A separate fire system is incorporated, charged by two 250 gallons per minute diesel-driven pumps connected to the water storage tanks.

Another 193-mile pipeline is under way so that Multan in South Punjab may have the benefit of the Sui natural gas. In the meantime, power stations and factories at Karachi, Hyderabad, Rohri and Sind are switching from coal and furnace oil to Sui natural gas.

Beginning with land clearance over a 40ft wide right-of-way, construction work commenced on the Sui–Multan gas pipeline project in October, 1956. The first joint was welded on December 18 and within a month 37 miles of pipe were strung, welded, coated, wrapped and laid in the ditch. The illustration shows a pipe string being coated and wrapped. The main line spread camp was moved from Dohli to Jamaluddin Wali, 90 miles away, and most of the heavy equipment had to be ferried across the Indus by pontoons. The construction of the 112 miles of the pipeline between the Indus and the Sutlej rivers was completed early in March, 1957. The crossing of these two rivers presented a formidable problem. The crossing of the Indus, which is flooded to a width of 7 miles in the rainy season and sends its waters down at a speed of about 10 knots, can be accomplished only during the winter months (December–February), and had to wait until the end of 1957. A construction camp was set up on the south bank of the Sutlej and all the special equipment needed for excavating a trench 3 miles long and 27ft below and across the bed of the Sutlej, consisting of pontoons, dewatering equipment and a dredger, was collected on site. Drive point wells will be sited at 5ft intervals and connected to a high-capacity pump to allow the ground water level to be lowered so that excavation work may proceed in a comparatively dry condition. Construction of repeater stations, built at approximately 35-mile intervals along the line, and designed to house both the radio and cathodic protection equipment, progressed steadily in the early months of 1957. The Sutlej River crossing camp was linked by high-frequency radio with the office of the chief engineer in Karachi and maintained a communications link between the camp and headquarters.

In July, 1957, the Sui Gas Transmission Company completed the 217-mile long Sui–Multan gas pipeline with the unavoidable exception of the 6-mile Indus crossing. The most difficult part was laying the 7000ft of pipe across the Sutlej at a depth of 27ft below the bed of the river. This was facilitated by the use of special dewatering equipment, which lowered the underground water level by 15ft to 17ft, thereby creating dry conditions for the excavation and removal of 1,500,000 cubic feet of earth and sand between the ground level to water level at this river crossing. The underwater crossing of the Sui–Multan gas line across the Indus River has been postponed, and instead a new 83-mile long, 10¾in diameter, line is being laid to make Sui gas available by mid-1958 from the Rohri headquarters of the company, to the completed portion of the 16in diameter Multan line east of the Indus. This decision was taken in view of the great cost of constructing a reliable underwater crossing of the river. Following the completion of the Guddu barrage adjoining the proposed underwater crossing site of the Sui-Multan gas transmission line, it is planned to complete the line from Sui to Multan by installing a 16in section across the barrage itself. When this job is done the 10¾in line will be available for recovery and use for pipeline extensions beyond Multan. The company has completed four repeater stations installed with diesel-driven generators to be replaced later by gas-engine-driven electric generators. To ensure high-frequency radio communication it has set up two 150ft high steel pylons at Multan and Shujabad and is installing a third one at Uch. Construction work is under way on the 140,000kW power station near Multan, for which turbines, boilers, plants and other machinery are expected to arrive in time to enable installation to be commissioned by mid-1959. By the end of June, 1958, however, Multan and other places along the pipeline will be able to get Sui gas for industrial purposes.

The external diameter and wall thickness of the Sui–Multan pipe are 16in and $\frac{5}{16}$in respectively, the same dimensions as the pipe employed on the 350-mile Sui–Karachi line. Half of the pipe for the Multan contract is being provided by Stewarts and Lloyds and the balance by Dalmine, of Italy. It is possible that a decision may be made in the near future to extend this line from Multan through Lyallpur and Lahore, a distance of 200 miles, to benefit industrial consumers in the region.

By mid-1957 more than a hundred industrial and commercial consumers were using Sui gas in West Pakistan. They included cement works, cotton mills, power stations, car manufacturers, glass works, steel re-rolling mills, bakeries, soap works and brick kilns. In October a contract was awarded for the building of an ammonia plant at Multan to a French group by the Pakistan Industrial Development Corporation. It will have a daily production capacity of 200 tons of ammonia and will be equipped to convert half this amount into urea and the rest to other ammonia fertilisers. The French consortium is to give technical assistance to Pakistani staff during the first two years of operation.

Direct comparisons between the price of gas and oil are not possible because of price variations in diverse areas, the differences in efficiencies of various processes and operating conditions in disparate industries. On an average the cost of gas is 5 per cent less than that of the furnace oil on present prices based on the gross calorific values of both fuels, but the operating efficiency of gas may be as much as 40 per cent more than oil in certain treatment processes such as glass making. Other advantages attached to gas are not readily assessed, however. Its use saves fuel losses, and being easily controllable automatically or manually it saves on pumping, heating or atomising. It is available at the turn of a tap and it saves storage, handling and transportation charges. The price of gas to general industrial consumers was reduced by one anna per 1000 cubic feet, from the beginning of this year.

Taking the calorific value of furnace oil as 16,600 B.Th.U. per pound and of Sui gas as 975 B.Th.U. per cubic foot, the actual savings to consumers in various areas are shown in the following table :

Location	Savings effected by use of gas, per cent
Landhi Trading Estate (bulk lorry delivery)	8·44
Sind Industrial Trading Estate (bulk lorry delivery) ...	5·70
Hyderabad (rail tanker delivery)	5·80
Sukkur (rail tanker delivery)	9·70

When these direct savings are compared with the other advantages of gas over competitive fuels the economies of using gas are readily apparent. In 1956 Sui gas saved Pakistan from importing 160,000 tons of furnace oil which would have cost the country Rs. 15,000,000 in foreign exchange, besides obviating strains on shipping, rail and road facilities to handle this liquid fuel.

The first gas well of East Pakistan was brought in as a producer on July 20, 1957, at Sylhet. Its production through 2in tubing gave a flow of nearly 15,000,000 cubic feet of gas per day. Completion of PPL's third well marks the beginning of the development of the Sylhet gasfield, reckoned to make a major contribution

to East Pakistan's industrial progress. Presence of natural gas in Sylhet was first discovered in May, 1955, when PPL's first test well blew out through a crater some 200 yards from the well, and the emerging gas caught fire, destroying well, drilling equipment and industrial and residential establishments. Drilling of Sylhet Well No. 2 began in May, 1956, but was abandoned due to the high pressures encountered, and additional seismic work was carried out to select a location for a new well. The latest indications are that there is a proved reserve of 150,000 million cubic feet of gas, while the possible reserves may well exceed 210,000 million cubic feet, with a heat content of about 1000 B.Th.U. per cubic foot.

Sylhet natural gas is purer than the Sui gas and will therefore not require the complicated and expensive purification plant as at West Pakistan, and is of great potential value as fuel since East Pakistan is deficient in energy sources. Projects and industries reckoned to benefit most from the availability of Sylhet gas are thermal power stations for electricity generation, production of synthetic fertilisers, cement works, glass manufacturing plants, brick kilns, &c. A report on the Sylhet-Dacca gas pipeline was submitted to the Pakistan Government by P.P.L. With the discovery of high-pressure natural gas in Sylhet, East Pakistan, in mid-1955 and confirmation by further drilling in August, 1956, it became apparent that a potential source of indigenous fuel existed there. Reserves of 70,000 million cubic feet can be taken as proved, while the probable reserves are likely to be of the order of 300,000 million cubic feet. P.P.L. have in hand a seismic survey of the Sylhet structure and are planning to drill a development early this year to test the gas bearing zone. The amount of gas probably recoverable is equivalent to 7,000,000 tons of oil and is sufficient to supply 20,000,000 cubic feet per day for forty-one years.

It is reckoned that the actual consumption in the Dacca area will be 9,000,000 cubic feet per day by 1959 and 20,500,000 cubic feet by 1965, including 5,000,000 cubic feet for the projected fertiliser plant. In addition to power and fertiliser production, it is likely that the gas would be used for the cement works at Chattak. To transport gas from Sylhet to Dacca it will be necessary to construct a high-pressure transmission pipeline of 8in diameter and 145 miles in length. This provides for a maximum ultimate capacity of 24,000,000 cubic feet per day, without compressors, assuming an inlet pressure of 1200 lb per square inch gauge.

The report recommends that the pipeline follows the main road going south-west from Sylhet to the Kusiyara River, continues southerly to Shaistiganj, roughly parallel to the East Bengal Railway line from Shaistiganj to Itakhola, veers west, and then south to a point on the Demra road 5 miles east of Dacca. The project must be so organised that construction can begin about December 1 and be completed before the monsoon starts in mid-May. If approved, construction might be commenced in December, subject to delivery of pipe and ancillary equipment, and completed by May, 1959, by which time the Shaistiganj thermal electric station is scheduled to have been in operation for one year. The scheme envisages a headquarters station at Sylhet, a terminal station at Dacca and a repeater station adjoining Itakhola. Provisions for high-frequency radio and very-high-frequency radio communications have been included, as well as those for complete cathodic protection.

With the greater bulk of the industry of East Pakistan concentrated in the Dacca area the pipeline would give great impetus to industrial development in East Pakistan by providing a cheaper source of fuel at Dacca and along the route of the pipeline. The use of Sylhet gas in the Sidharaganj thermal electric station would also allow lower electricity rates in the area, thus providing further stimulus to industrial expansion. Saving in foreign exchange through reduction in imported furnace oil requirements is another advantage offered by the scheme.

Jodrell Bank Radio Telescope

We print below an excerpt from the speech made by Sir Raymond Street before the Court of Governors of the University of Manchester on November 12. It relates to the radio telescope at Jodrell Bank, to its performance, to its cost and to the appeal for funds which the University is to make.

BEFORE concluding I wish to make special reference to the topic of the radio telescope at Jodrell Bank which has been mentioned, I imagine, in every newspaper in the world, or very nearly so, in the last few days, because of the American lunar probe experiments. You might think it strange if a subject of such immense interest to the world at large at this present moment were not to be mentioned at a Court Meeting of the University to whose credit this unique achievement stands.

I acknowledge that we have been subjected to criticism as regards the financial and administrative arrangements at various stages of the history of the enterprise. We at the University have resisted every temptation to enter into public discussion of such criticism which might, in any way, diminish, or lead to misunderstanding concerning the immense achievement at Jodrell Bank. For we believe that the radio telescope cannot be described in lesser terms. It is an immense achievement whether viewed as a piece of scientific equipment conceived by Professor Lovell or as an unparalleled feat of engineering designed by Mr. Husband. Every day that passes emphasises these facts and the time is at hand when all due acknowledgments to the help we have received from many sources, may be made.

In the meantime there are one or two things I wish to emphasise to-day. We have received continuous encouragement and assistance from the Press. Its support has been, at every stage, invaluable. Unfortunately, however, there has been some suggestion that British industry has been unhelpful. The facts are far otherwise. Although we have not yet made any formal appeal for the funds which will enable us to clear off the deficit on the cost of the instrument, we have already received a sum of £10,000 from Henry Simon, Ltd., and £10,000 from Simon-Carves, Ltd. And throughout the whole undertaking the University has been sustained by the co-operation—almost amounting to partnership—of the many firms engaged on the project and chiefly by the main contractors, the United Steel Companies, Ltd. That company's co-operation in the building of the telescope has, I feel sure, caused them on many occasions to rate the final achievement much above purely financial consideration. Indeed we know full well that from the company's point of view their association with the University in this venture has not been financially profitable, but in view of the novel character of the structure and its great importance to scientific developments in this country, they have never failed to meet our requests. We are greatly their debtors on this account and in my opinion the nation and world of science are also in their debt. These remarks of mine will make clear that the University already has cause to be grateful to British industry in this matter.

As to the criticisms made at various points I think the Court of Governors will feel as I do that the whole story reflects a brilliant light of credit on all concerned. The criticisms arose from the fact that the Public Accounts Committee, in the perfectly proper execution of their public duty, began to discuss in public some aspects of the finances which the University was not at liberty to deal with in equal publicity because of the complexities of its legal and honourable commitments to other parties. This made it possible for the public to think the finances had in some way been handled inadvisedly. This was not really so. True, there were developments which nobody foresaw at the outset. But I venture to assert that no comparable pioneer enterprise has ever proceeded from conception to fulfilment without at least some unexpected developments. The fact is that Britain is first in the field with a new scientific instrument of fantastic quality, at a total cost far below what others will be soon paying for similar instruments and Britain's contributions to a new field of knowledge will in consequence for ever redound to our credit. It is true we at the University might have taken different decisions as each of the several unforeseen developments in our problems, scientific or financial, emerged. So might the generals in command of any military campaign. But the proof of the pudding, for generals, is the success of the campaign and the proof of the pudding for the University is success in achieving the original conception in time for it to play an irreplaceable part in historic scientific events.

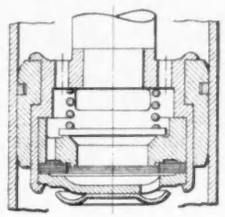
As to the amounts still outstanding in the total cost I am sure we will be able to attract satisfactory contributions. Before the end of this month we shall be addressing an appeal to those whom we believe may be disposed to help us. We feel confident that there will be many who will be extremely keen on this great national achievement, resounding round the world from the Brussels Exhibition to Cape Canaveral and, no doubt, Moscow and will be ready and willing to help the University to wipe off what is relatively a small debit balance and so free us for scientific work of the first order of importance and urgency. Anybody who feels moved to give before being formally asked to do so and believes with the soothsayer that he gives twice who gives quickly will find our Treasurer already primed with a book of receipts.

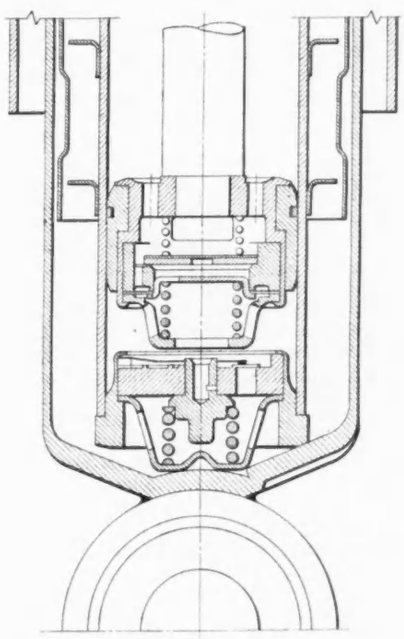
More will fall to be said about this Manchester University achievement in coming days. Meanwhile we can all rejoice in an accomplishment which will for ever reflect honourably on the vision and enterprise of the University.

Redesigned Hydraulic Dampers

Hydraulic dampers for vehicle suspensions are necessarily light and correspondingly highly loaded: their design is a difficult compromise between initial and maintenance cost. The latest Girling telescopic unit renders maintenance relatively undemanding in skill, since it is never serviced; a unit that has deteriorated is scrapped and renewed.

THE new Girling C.S.V. damper is a completely sealed unit which is discarded and replaced when any deterioration becomes apparent. While it is realised that different settings are needed on different cars according to the roads they use, and on the same car according to the driver, it is believed that by sacrificing any means of adjustment a cleaner and, hence, more reliable product can be secured. It is also admitted that manufacturers will not be prepared to hold at all their service depots stocks of dampers of different settings, but it is hoped that the performance of the damper will be sufficiently good to reconcile the designer to, virtually, designing the car around the damper. The particular virtue of this damper is claimed to be long-term stability: chrome surfacing of the piston-rod, the absence of screw fittings, and the design of the valves is expected to reduce the rate of departure from initial settings by a factor of two or more. The life achieved in service will, clearly, depend on the installation, but is expected to be a fairly large fraction of a car life. The new damper, in two sizes, 1in and 1⅜in, is intended to supersede all Girling telescopic dampers at present in production for cars.





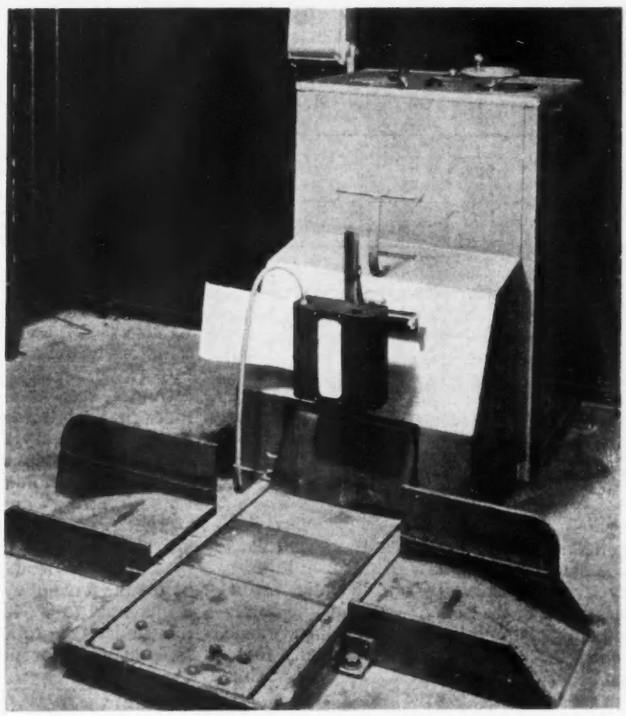
Section through the "C.S.V." completely sealed damper at the unsprung end. Above is seen a piston of the design now superseded

The construction is basically conventional, with a working cylinder inside a reserve cylinder, and a cylindrical shield moving with the piston-rod, but there is a fourth cylinder fitting within the reserve. Oil passing through the piston-rod guide bush emerges outside this tube, and to enter the reservoir must pass through the narrow annulus between the tubes. This space is so constricted that capillarity keeps it full of oil, so that aeration of the oil passing the guide is reduced. The oil is also brought into intimate contact with the outer wall of the reservoir, and although the wall here is partly screened by the outermost tube, some reduction in oil temperature results (see also below). The lower part of this drain tube is swaged to co-operate with flanges on the outer wall of the working cylinder to baffle the movement of the reservoir oil excited by the motion of the unsprung masses, and therefore reduce aeration. Our section through a complete damper shows these four concentric tubes and the baffles above the reserve of oil.

The short-term stability, or dynamic loss, is claimed to compare favourably with other dampers on the basis of tests carried out at a temperature of 150 deg. Cent. It is realised that this comparison is not valid, as would be one at equal rates of energy conversion, but it is believed that only small changes in heat dissipation can be designed in without markedly affecting the cost of the product, and that competitive dampers are therefore likely to run at closely the same temperature.

The basis for the claimed long-term stability of settings (in the case of the 1⅜in unit used on all Jaguar cars, around 10 per cent or less after 750 miles on *pavé*) is the design of the valves. In the simplest terms, low-rate springs have been used so that a measure of permanent set does not greatly reduce the force exerted. In our drawing it can be seen that the rebound valve in the piston consists of an annular diaphragm held on to an annular seat by a coil spring in compression. (Bleed during slow movements takes place through radial cut-outs in the topmost lamination of the diaphragm.) This contrasts with the previous design of piston, in which the spring also was an annulus, and the deflection represented a large strain. The new valve is claimed to be particularly quiet in bleed operation, and when this feature is not important a short path bleed is employed, this consisting of a small hole in the shim seen on top of the (bump) transfer valve plate, and a hole, shaped to form a baffle, in the plate.

The inlet valve is a very lightly loaded steel shim, since the pressure difference to effect recuperation is exceedingly small. It will be noticed that all the valves are assembled by spinning over the carriers: to determine the optimum settings for a given car, special dampers with screwed-up adjustable valves are used. There are normally supplied five different bleed settings in both bump and rebound directions, with a choice of setting at, normally, 21in per second over a wide range: for the 1in unit, between 135 lb and 450 lb in rebound. As has been made clear above, setting is carried out by no one other than Girling, Ltd.



Wheel vibrator for assessing the condition of dampers: notice the mechanically driven recording chart

To afford a check on the condition of dampers in service, Girling uses and recommends the Beissbarth wheel vibrator illustrated. A car is manœuvred so that one wheel rests on the tray of the vibrator, and a stylus is mounted on the wheel hub opposite the centre of the wheel. The moving chart recorder is held against the stylus by a soft spring, thus obtaining a record of wheel travel in the vertical direction. The frequency of excitation can be varied to find resonance, and a useful indication of damper effectiveness can be obtained by recording the decay of the oscillation when the excitation ceases. The results are, of course, only comparable between cars of the same design.

RADIO AND ELECTRONIC COMPONENT SHOW, 1959.—The sixteenth annual Radio and Electronic Component Show, organised by the Radio and Electronic Component Manufacturers' Federation, is to be held at Grosvenor House and Park Lane House, London, W.1, from April 6 to April 9, 1959. Admission (from 10 a.m. to 6 p.m. daily) is by invitation only; applications for tickets to be made to the Secretary, R.E.C.M.F., 21, Tothill Street, London, S.W.1.

Metallurgical Topics

Nitrogen in Stainless Steels

A SUMMARY of six papers on nitrogen-bearing austenitic steels presented at the Electric Steel Conference, A.I.M.E., Pittsburgh, on December 5, 1957, is given by E. C. Wright.* The low-carbon nitrogen-manganese-chromium steels resemble the usual chromium-nickel austenitic steels, but, in applications requiring a non-magnetic alloy, have been more resistant to transformations during magnetic conditions than those more commonly used. The matter of nitrogen solubility becomes, therefore, important. Langenberg and Day, using the published binary diagrams, calculated the maximum nitrogen content in any given series of complex alloys containing the elements shown in Fig. 1, where S_n is "the nitrogen

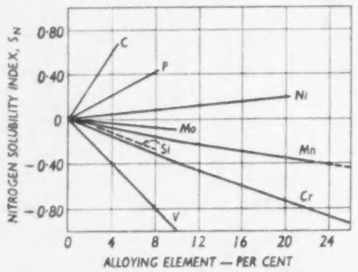


Fig. 1—Nitrogen solubility index in steels at 1600 deg. Cent. (2910 deg. Fah.) as affected by the presence of various common alloying elements. Elements with lines inclined upwards decrease nitrogen solubility in liquid steel ; elements with lines inclined downwards increase nitrogen solubility

solubility index." The authors calculated the maximum solubility of nitrogen in thirty typical alloy steels by an algebraic method described in the paper. Melts of the corresponding compositions were then made, when the nitrogen contents actually found agreed closely with those predicted. Thus, an 80–5–15 Fe-Cr-Mn alloy contained 0·13 per cent of nitrogen, against 0·14 per cent predicted, a 74–18–8 Fe-Cr-Ni alloy contained 0·19 per cent of nitrogen, as had been computed ; a 93–2–5 Fe-V-Mo alloy contained 0·077 per cent nitrogen, compared with 0·078 per cent predicted, and a 56–16–16–12 Fe-Cr-Mn-Ni alloy contained 0·27 per cent of nitrogen, 0·26 per cent having been predicted.

One must consider not only the solubility of nitrogen in liquid steel, but also that after solidification, for the evolution of nitrogen can cause porosity in the solidifying metal. To throw further light on this relationship, two series of melts were made in an induction furnace under one atmosphere of nitrogen. The base composition was 16 per cent chromium and 15 per cent manganese, respectively ; nickel being varied in both series from 0 to 10 per cent. To ensure saturation, more nitrogen than the predicted maximum was added as nitrogen-bearing ferro-chromium. Forty minutes after the last addition, a 1in bar was cast. It was found that, with increase in nickel content, the solid solubility of nitrogen also increased, although, as seen in Fig. 1, nickel decreases the solubility of nitrogen in the molten alloy. This anomaly can be explained by the fact that nickel is an austenite stabiliser, and has little effect on the solid solubility of nitrogen in austenite, and no ferrite was found in the high-nickel alloys when solidified. The authors quote a number of compositions which can contain nitrogen at any desired level up to 0·3 per cent, with no trace of porosity from excess nitrogen dissolved in the molten metal.

A similar paper by G. R. Adams, J. Thompson and W. O. Binder contained the results of some ninety melts of a 0·06–0·08 per cent carbon, 0·4–0·5 per cent silicon, 17·5 per cent chromium steel in a basic-lined induction furnace. The composition also included from 0 to 5 per cent of nickel and 7 to 14 per cent of manganese, with varying amounts of nitrogen up to eight parts per million. Ingots cast 2in square were sectioned longitudinally for porosity, attributed by the authors solely to the rejection during solidification of nitrogen in excess of the solid solubility limit. The results, shown in Fig. 2, agree very well with those obtained by Langenberg and Day, shown in Fig. 1. The maximum allowable nitrogen content in such steels, if the production of gassy ingots is to be avoided, is thus readily determinable.

The Kjeldahl wet chemical method for nitrogen analysis in electric furnace steels was discussed in considerable detail by R. H. Colin, who doubted whether uniform samples could be obtained from the electric furnace bath. A bomb type of mould has therefore been used to obtain samples at four different locations and depths of the bath. Preliminary tests show very uniform results in all grades except Type 321 (18–10–Ti) if three factors—homogeneous distribution of nitrogen in the bath, reproducible sampling practice and accurate analysis—are under control. The amount of nitrogen present ranged from 0·029 to 0·040 per cent before the ferro-alloy addition. In final tests, it increased to 0·040 per cent, from absorption under the arc and in teeming. Several rapid methods for nitrogen in the preliminary

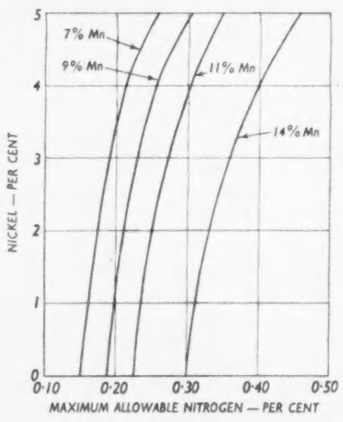


Fig. 2—Nitrogen contents to the right of any curve for the chromium-manganese steels will give rise to gassy ingots. Base composition of the steel is : 0·06–0·08 per cent carbon ; 0·4–0·5 per cent silicon ; 17·5 per cent chromium

tests (before nitrogen alloy addition) were described, some of these taking only some ten to twenty minutes. According to Colin, such nitride-forming elements as titanium, zirconium, vanadium, niobium and tantalum were finally dissolved by the boiling dilute mixture of sulphuric and phosphoric acids.

As distinct from aqueous methods of determining nitrogen, this conference also included three papers describing vacuum fusion processes in great detail, covering a description of the apparatus, the methods of operation and the results obtained. Contrary to the opinion, expressed above, that complex nitrides can be determined by aqueous methods, it was positively stated that titanium, zirconium and other refractory nitrides can be determined only by the vacuum method.

Precautions When Chromium-Plating Steel

AN amendment to Federal Specification QQ–C–320 requires the shot-peening of steel before chromium-plating for all applications where fatigue strength is considered important. This matter is discussed by B. Cohen,* who divides fatigue in steel into two classes : (*a*) high-stress, low-cycle fatigue ; (*b*) low-stress, high-cycle fatigue. Chromium electrodeposits cause a drastic reduction of the fatigue strength of the basis metal, this being attributed by Cohen chiefly to high residual tensile stresses in chromium plate. It is generally known that this prejudicial effect increases with the hardness and tensile strength of the steel. Hydrogen embrittlement of steel also increases with increase in tensile strength, this explaining the need for baking after chromium-plating. The effect of hydrogen embrittlement is predominant in high-stress, low-cycle fatigue and becomes most pronounced in static failure. The effect of chromium-plating is most pronounced in low-stress, high-cycle fatigue or at the endurance limit.

Samples machined from $\frac{5}{8}$in diameter bar stock of S.A.E. 4340 steel (0·25–0·35 per cent carbon, 0·050 per cent (maximum) sulphur, 0·040 per cent (maximum) phosphorus, 0·40 to 0·60 per cent manganese, 0·80 to 1·10 per cent chromium, 0·15 to 0·25 per cent molybdenum) were heat-treated in two groups to Rockwell C46 (97 tons per square inch) and Rockwell C53 (116 tons per square inch), respectively, being then finish-machined and super-polished. One-third of each group were shot-peened in accordance with Specification MIL–S–13165A, using a shot-peening intensity of 0·010 as determined by the Alman strip method given in this specification. All test pieces were plated in a conventional chromium-plating bath containing 33 oz per gallon of chromic acid with a $CrO_3 : SO_4$ ratio of 100 to 1, other details being : current density, 2A per square inch ; time, three hours ; chromium thickness, 3·5 mils ; bath temperature, 130 deg. Fah. After plating, one-half of each group were baked at 375 deg. Fah. for three hours.

In fatigue tests made on a rotating beam machine of R. R. Moore type, the chromium-plated, high-strength (116 tons per square inch) steel specimens showed only a slight decrease in fatigue strength as compared with the drastic decrease (as much as 50 per cent) obtained with specimens not shot-peened before plating. Shot-peening of medium strength (97 tons per square inch) steel actually increased the fatigue strength. Shot-peened, chromium-plated specimens baked at 375 deg. Fah. for three hours after plating had an endurance limit 18 per cent greater than that of the unplated metal. It should be recognised that high-strength steel has a greater resistance than medium-strength steel when shot-peened with the same

* *Metal Progress*, July, 1958, page 136.

* *Metal Progress*, July, 1958, page 112.

intensity, being thus less cold worked and having a thinner layer of residual compressively stressed material at the surface. A higher shot-peening intensity, giving greater plastic surface deformation, would probably increase its effectiveness with high-strength steels.

Guide to Forging Methods

METHODS of forging are the subject of an editorial report,* prepared with assistance from various quarters. There are four types : (1) smith forging ; (2) drop forging ; (3) machine (or upset) forging, and (4) press forging. Smith forgings include hammered forgings, hand forgings and flat die forgings. Although final forming may require a few simple hand tools, no impression dies are used. The smith hammer may include the helve and power hammer in sizes from 15 lb to 500 lb, the steam forging hammer in sizes from 200 lb to 20,000 lb, and the forging press (not the type used for impression die forging) in sizes from 200 to 15,000 tons.

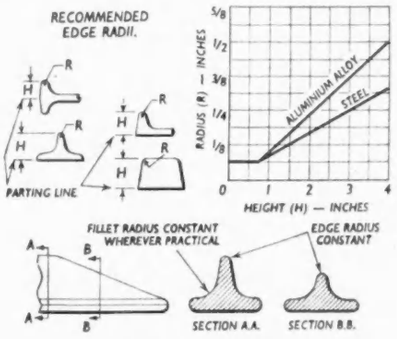


Fig. 1—Recommended edge radii for forgings

Drop forging involves regulated intermittent pressure of the drop hammer, using dies that contain the shape and contours of the finished forging. The top die is fastened to the hammer ram, and the bottom one to the anvil cap of the drop hammer. These "closed impression" dies are carefully aligned to ensure accuracy of dimensions of the finished forging. The use of closed impression dies is also characteristic both of upset and press forging. Machine or upset forgings are made by using a horizontal type

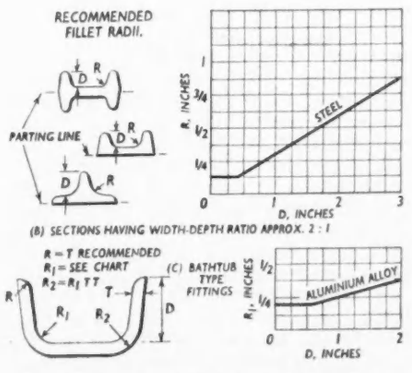


Fig. 2—Recommended fillet radii for forgings

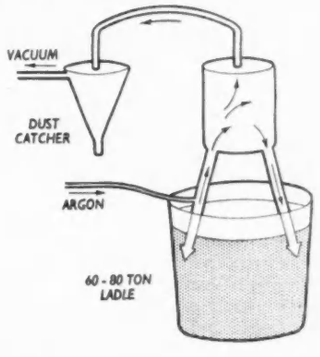
of double-acting press, which pushes or squeezes the plastic metal into the die cavities ; the press being commonly known as an "upsetter." Press forging also involves the pushing or squeezing of metal into a die impression, but in a vertical—rather than a horizontal-type press. In terms of quality of the resulting forging, all three methods using closed-impression dies are comparable. Design of the forging is important. One design requirement is that of forging draft, the slight taper given to the sides of a forging to permit its withdrawal from the finishing die impression. In normal practice, the angle for outside draft is 7 deg. ; for inside draft, 10 deg. The use of generous radii and fillets provides more room for the change in direction in metal flow, results in less wear of dies and reduces costs. Sharp radii and fillets tend to give rise to unfilled sections, forging laps and cold shuts. Recommended edge radii are shown in Fig. 1, and recommended fillet radii in Fig. 2. Pockets and recesses in the forging necessitate corresponding raised sections in the dies. It is more difficult for the metal to flow over these. If they are too thin or too high, they will heat up much more rapidly than the rest of the die. In designing ribs, the height should be as small as possible and there should be a full radius at the top. Large draft angles on the sides of the ribs are also advisable.

* *Iron Age*, August 21, 1958, page 94.

Vacuum Flow Steel Degassing

A VACUUM flow steel degassing process developed by the Henrichshütte, one of the oldest steel plants in the Ruhr, is described by F. W. Starratt.* It is used to avoid the incidence of flaking in heavy castings and forgings, resulting from contamination by hydrogen and other gases, and has been in commercial use for over six months with apparent success, being capable of bringing the hydrogen, nitrogen and oxygen contents of all types of steel to proportions as low as those obtained in vacuum casting techniques. The operation is carried out in normal steel ladles of capacities between 60 and 80 metric tons, and is adaptable to all types of carbon steel—rimming and killed—as well as most alloy steels.

A diagram of the apparatus is shown below. The cylindrical container with two



Schematic diagram of the vacuum flow degassing apparatus

pipes protruding is lowered into the steel bath in the ladle until the pipes extend below the level of the metal. The vacuum pumps consist of an initial series of three Roots pumps in parallel with a capacity of 28,000 cubic metres per hour. This is followed by a second series of two Roots pumps in parallel with a capacity of 6000 cubic metres per hour, and one further Roots pump of 1000 cubic metres per hour capacity. The final pump is a water-ring pump, with an eccentric paddle wheel type rotor, having a capacity of 750 cubic metres per hour, exhausting the gases through a pipe into the atmosphere. The vacuum created in the chamber causes the metal level to rise in both pipes, but small quantities of argon gas are blown into the lower end of one of the protruding pipes, thereby causing a flow of metal up one of the connecting pipes, through the container, and down the other pipe. A vacuum of 0·1mm Hg is maintained in the container. Between the container and the vacuum pumps is a cyclone dust catcher, as shown in Fig. 1. The degassing process is continued until the proper gas level has been reached. Continuous samples of gas are taken from the final pump, and analysed in an Orsat apparatus, the end point of the process being determined from this analysis. Although operating figures have not yet been released by the firm, the capital costs are obviously quite low.

* *Journal of Metals*, July, 1958, page 465.

Determination of Forming Limits for High-Strength Metals

A NEW method of assessing forming limits for high-strength metals, including titanium, has been devised by Chance Vought Aircraft Inc., Dallas.* Samples of sheet are inserted between dies of special design in a hydraulic press of Guerin type, so as to produce an angle section with a series of dimples increasing in depth across the angle. The die design is such that the forming capabilities of the material can be assessed by observing which of the dimples have fractured. One set of dies is capable of testing sheet 0·010in to 0·040in thick, and a second set sheet 0·050in to 1in thick. Tests can be made at the rate of forty to sixty per hour. The samples need not be machined to close limits, and special preparation of the edges is not required. It is claimed that this method, for which patent application has been made, permits accurate prediction of the limits for forming titanium without rupture.

Spectrographic Analysis of Oxygen in Titanium

A SPECTROGRAPHIC method for the analysis of oxygen in metals, which had been applied to carbon steels, has been further investigated by R. E. Heffelfinger and W. M. Henry,† to find out its suitability for the analysis of oxygen in titanium. The apparatus, which is described and illustrated, consisted of normal spectrographic equipment and a specially constructed arc chamber, designed to hold thirteen electrodes, with gas-vacuum apparatus with which absolute pressures of about 5×10^{-4}mm Hg were obtainable. Oxygen was released from the titanium into an argon atmosphere by striking a direct current arc on the titanium sample and a platinum film supported on a graphite electrode. The optimum ratio of platinum to titanium was 5/1. The spectra of oxygen and argon were photographically recorded and the ratio between intensities of selected oxygen and argon lines was determined. By comparing these intensity ratios with similar ratios for titanium samples of known oxygen content, a method of oxygen determination accurate within ±5 per cent is obtained.

The standards used in the investigation were analysed by the vacuum fusion technique, but it may ultimately be possible to produce further samples synthetically. By recording line intensities with photo tubes instead of film, the precision of the method could be increased by a factor of two or three. The method was rapid and the installation of equipment quite economical if applied in a laboratory already provided with the basic equipment for spectrographic analysis. Two operators should be able to complete twenty-four to thirty-six samples in eight hours.

* *American Machinist*, August 25, 1958, page 80.

† Battelle Memorial Institute. Titanium Metallurgical Laboratory. *TML* 98, April 18, 1958.

LETTERS AND LITERATURE

Letter to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

MR. WATKINSON'S MISSING LINKS

SIR,—Your editorial of October 31 includes the statement that a network of urban motor roads is essential, and "this is one of the cardinal facts in London's road problem." May I add a comment to this ?

Plans for major new roads in London must necessarily be long-term projects, entailing very large expenditure, and they should not be allowed to obscure the still greater importance of the immediate elimination of bottlenecks in the existing road system. The current road programme is concentrating on improvements of this type to the system of roads and, coupled with regulation of street parking, it should give quick and cheap results. New motor roads when they are tackled will need very careful planning so as to avoid creating new bottlenecks where they join into the existing street system. It will also be necessary to ensure before starting them that additional off-street car parking provision would be provided for the additional traffic brought into the city.

But there is a better way—the underground railway. The Victoria Line, as proposed by London Transport—to run between S.W. and N.E. via Green Park, Oxford Circus, Euston and King's Cross, Finsbury, Tottenham and Walthamstow—would do more, at less cost, towards solving the traffic problem than the construction of new roadways across London. The Victoria Line could carry 32,000 passengers in one direction in one hour. To move the same number of people by private car would require a motor road of fourteen lanes. The Victoria Line would cost, with rolling stock, about £55,000,000, but lack of finance at present stands in the way of this vital improvement for London, for which Parliamentary powers have already been obtained.

R. M. ROBBINS,
Chief Public Relations Officer,
London Transport Executive.

55, Broadway,
London, S.W.1,
November 19, 1958.

Book Reviews

Analysis and Control of Non-Linear Systems. By V. H. KU. The Ronald Press Company, 15, East 26th Street, New York 10, N.Y. Price 10 dollars.

THE analysis of non-linear systems is a subject on which much has been written and much will no doubt continue to be written in the future. Advances are no doubt being made, and the introduction of phase-plane concepts adds further power to the analyst when low order systems are under consideration. However, the extension of this method to higher order systems, where multi-dimensional phase space is the working medium, is a far cry from the easily conceived phase-plane, and considerable effort may be involved before this tool is sufficiently mastered to make it useful in its own right. Just as the advocates of relaxation processes built up on the basic concepts and entered the third dimension, so the phase-plane is now becoming the phase space and methods are being stretched by earnest researchers to a point where the complication of the tool is out of proportion to the relative importance of the problems being solved.

This book, however, is an excellent and well written account of various types of differential equations with notes on their solution. It starts off by defining a non-linear system, broadly speaking, as a system in which the principle of superposition no longer applies, and introduces the phase-plane idea in the conventional manner. Various analytical methods of solving discrete non-linear problems, of interest largely to the pure mathematician, are outlined and other graphical methods receive scant mention. This chapter, as indeed the whole book, is liberally spiced with well chosen examples and the complete solutions presented make it a pity indeed that some form of cataloguing has not been attempted.

The second chapter gets down to physical systems and shows how linear equations of mechanical and electrical systems are built up, and how the normal functions of nature soon turn into non-linearity those phenomena which we fondly regard as strictly linear. The analogy between electrical and mechanical systems is developed in some detail, but the chapter in the main concentrates on description rather than solution. Coming on to specific non-linearities, the third chapter concerns itself with non-linearities in the restoring force and deals mathematically with some of the simpler forms of single equations. Phase-plane and acceleration plane solutions are shown and both mechanical and electrical systems are discussed, although this has little real bearing on the theme of the chapter which is largely mathematical.

The fourth chapter continues in the same vein except that in this case damping is introduced. Acceleration plane methods are described, but other methods such as power series and iteration are considered. An interesting numerical example of a step-by-step method for solving the appropriate phase-plane equation is given, and it is in examples such as this that this book is unusual and quite refreshing. Various equations taken from physical problems such as a pendulum and a synchronous motor are considered. A short chapter on the classification of singularity follows and this again is of interest to the pure mathematician rather than the system analyst.

In the sixth chapter autonomous systems, i.e. systems in which there is no external forcing function, are examined concentrating on those with non-linear damping characteristics. Various possible methods are outlined including a small perturbation approach. The next chapter considers non-linear systems with forcing functions and various possible means of solution are again outlined, in which Van der Pol's method for a particular form of equation is particularly well described. Following a highly mathematical chapter on sub-harmonics, Chapter 9 enters the more absorbing and much more complicated field of analysis of high-order non-linear systems and generally indicates, with satisfying mathematical proofs, that multi-loop systems can always be described by a single high-order equation and that phase space methods are then applicable. Various higher order equations such as that of Blasius and a third order equation from the field of fluid dynamics usually associated with Schlichting are discussed, and the problem of stability in such systems is touched upon. Going on to higher orders still, various multi-loop systems are introduced and the phase space approach to their solution discussed. A new technique termed "The method of simultaneous phase-plane equations" is introduced in which the simultaneous describing equations can be kept in separate form, hence facilitating solution. This may well prove a useful tool in practice but we feel that techniques are being stretched in this direction to a point where they may be of academic interest but hardly of much practical significance to the hard-pressed engineer who must have a solution.

The penultimate chapter is devoted to an analysis of non-linear servomechanisms and a very important topic, that of the introduction of non-linear elements to improve servo performance, is discussed. The possibility of various modes of operation is mentioned and stability criteria touched upon. The effect of backlash in various forms of servos is introduced and a possible non-linear control system for wide range input signals mentioned. The last chapter headed "Non-linear Control of Feedback Systems" commences on a philosophical rather than a practical note but gives some theory on the introduction of non-linear elements into both forward and backward loops. Various forms of non-linear feedbacks are discussed. Finally, one page is allocated to the most powerful method of analysis of non-linear systems of all, i.e. modern high speed computers. In practice, it is generally found that in an engineering system, once it becomes necessary to leave the realm of linear dynamics, the problems become so formidable that only computer techniques can cope ; it is indeed a worthwhile reflection that the most complicated equations considered in this book still represent relatively simple systems only and no analytical break-through in the field of analysis of non-linear systems is as yet apparent.

This is an excellent and well-written book in as far as it goes and serves as an admirable catalogue of simple forms of non-linear equations with accounts of various methods for their solution. But whilst synthesis of non-linear systems may be a job for the mathematician, analysis should surely be left to the computer engineer and books such as this, whilst interesting academic exercises, do not fall within the province of the practical engineer.

Nomograms for Chemical Engineers. By O. P. KHARBANDA, D.Ch.E., A.M.I.Chem.E. Academic Press Inc., New York. Heywood and Co., Ltd., Ingersoll House, 9, Kingsway, London, W.C.2. Price 80s.

THIS volume includes over 100 nomograms which have been collected from published literature, the selection being determined on the basis of giving the maximum coverage, and none being confined to one property of one compound. The nomograms are grouped in three broad divisions ; one contains those relating to physical properties, such as critical constants, latent heats, &c.; in the second are those pertaining to the various unit operations of chemical engineering, while

in the third division are grouped miscellaneous nomograms and a few charts. In each instance the basis of the nomogram is given, together with an explanatory example together with, in most instances, an indication of the degree of accuracy expected. Also included is a reference to the original source which forms a valuable guide to the literature. This volume, which is printed on large page size to give maximum accuracy, also has a plastic rule for quick and easy use. The book should prove of great value to all process chemical engineers, chemical engineers engaged in research and development, and also to students in chemical engineering, since it provides a means of quickly obtaining information, with a reasonable degree of accuracy (provided the relevant parameters are known) which is not directly available and which would otherwise involve consulting many books of reference and making certain calculations.

A Guide to Nuclear Energy. By R. F. K. BELCHEM. Sir Isaac Pitman and Sons, Ltd., Parker Street, London, W.C.2. Price 10s.

THIS small book, fitting into the pocket, was written for people without specialised knowledge. The author is well qualified to give a general Anglo-American picture, having himself been associated with nuclear engineering work on both sides (at present the other side) of the Atlantic. What are called the " basic principles of nuclear fission " are described by Major-General Belchem in the most elementary terms, after which he gives a simple account of the fission reactor. An attempt is made to classify the various kinds of fission reactor currently being developed or considered, and there is discussion of fuels, fuel processing, fuel elements, coolants, and the more important materials used in reactors. Rather surprisingly, at a time when " power from the sea " is so favoured a subject among popular science writers, fusion is not mentioned. The book ends with short paragraphs on some uses of radioactive tracers, medical diagnosis and treatment, and other applications of radiation.

While the literary style of the " Guide " may not satisfy every reader, the meaning will be discernible to most, and the diagrams are nearly all very clear. There is a short index, probably adequate for the purposes of the book.

Les méthodes scientifiques dans les techniques modernes : quelques écueils. By PIERRE VERNOTTE. Publications Scientifiques et Techniques du Ministère de l'Air, No. N.T.70. Service de Documentation et d'Information Technique de l'Aéronautique, Magasin C.T.O., 2, Avenue de la Porte-d'Issy, Paris (15e). Price Ffr.700.

THE spread of advanced scientific techniques into applied research and technology is not without its problems and dangers. In the present book, *Ingénieur Général de l'Air* Vernotte deals with certain aspects of the application of fundamental science and of mathematics to aeronautical studies, views which, however, are of significance to every engineer whose work brings him into contact with these disciplines. The scope of the essays may be gathered from the chapter headings : " Order and Disorder " deals with turbulence and servo-mechanisms ; " In the Tunnel " with scientific over-specialisation ; " Measurement and Scientific Thought " with the limitations of the quantitative ; " Over-learned Evaluation of Experience " with the relative importance of mathematical method and common-sense *vis-à-vis* experimental results. Finally, " Statistics and Experimental Physics " concerns some of the pitfalls occasioned by the use of that department of mathematics in experimentation and in drawing conclusions from experimental results.

Platinum in the Glass Industry. By H. MOORE, D.Sc., A.R.C.S., F.Inst.P. The Mond Nickel Company, Ltd., Thames House, Millbank, London, S.W.1. Free.

THE author, who is Emeritus Professor of Glass Technology at the University of Sheffield, provides in this well-produced 45-page booklet a general survey of the uses to which platinum is currently put in the glass industry. Pride of place is given to the improvements in optical glass that platinum has made possible. Considerable improvements in the quality of the product and the efficiency of its manufacture have also been brought about with other kinds and forms of glass. A striking case is that of glass fibre, and the author devotes a chapter to the manufacture of this material. The booklet deals, among other things, with the control of raw materials and composition in glass-making. The manufacture of commercial and optical glasses is described, and there are also chapters on experimental glass melts and the measurement and control of temperature in furnaces.

Radiography in Modern Industry. Eastman Kodak Company, X-Ray Division, Rochester, 4, N.Y., U.S.A. Price 5 dollars.

DATA on radioactive isotopes and their use have been included in this second edition of the Eastman Kodak Company's " handbook " on industrial radiography. Also added in this revised edition is material on image amplification, geometric enlargement and radiation monitoring, the sensitometric characteristics of Kodak films, and a guide to the selection of such films for both X- and γ-radiography.

While the book is bound to be more comprehensively satisfactory for the American reader than for others, it contains much of general interest and value. There are nearly 140 pages, profusely and clearly illustrated. The indexing is good, and bibliographies on radiography and protection are provided.

Books Received

Questions and Answers on Oxy-Acetylene Welding. By E. Molloy. George Newnes, Ltd., Tower House, Southampton Street, London, W.C.2. Price 12s. 6d.

Geological Structures and Maps. Second edition. By A. Roberts. Cleaver-Hume Press, Ltd., 31, Wright's Lane, Kensington, London, W.8. Price 12s. 6d.

Problems in Engineering Structures. By R. J. Ashby and A. H. Chilver. Edward Arnold (Publishers), Ltd., 41, Maddox Street, London, W.1. Price 16s.

Surveying and Levelling for Students. Second edition. By B. H. Knight. Contractors Record, Ltd., Lennox House, Norfolk Street, London, W.C.2. Price 21s.

Early Engineering Education at Toronto, 1851–1919. By C. R. Young. Oxford University Press, Amen House, Warwick Square, London, E.C.4. Price 31s. 6d.

A Textbook of Fluid Mechanics for Engineering Students. By J. R. D. Francis. Edward Arnold (Publishers), Ltd., 41, Maddox Street, London, W.1. Price 24s.

Tables for Solving the Laplace Equation Inside an Ellipse. By A. I. Vzorova. Cleaver-Hume Press, Ltd., 31, Wright's Lane, Kensington, London, W.8. Price 50s.

Hochwertiges Gusseisen (Grauguss). Second edition. By E. Piwowarsky. Springer-Verlag, Wilmersdorf, Heidelberger Platz 3, Berlin, Germany. Price DM.135.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

STEELS FOR USE IN THE CHEMICAL, PETROLEUM AND ALLIED INDUSTRIES

No. 1501–1506 : 1958. Price 25s. This revised series of standards for steels has been prepared as part of a comprehensive scheme of codes for pressure vessels for use in the chemical and allied industries. It supersedes the previous (1950) edition. There are four separate specifications : 1501, 1503, 1504, 1506—the numerical " gaps " having been left for possible allocation to other forms of material as and when necessary. This edition (eighty-four quarto pages) deals with plates, bars and sections, forgings and castings, and bars for bolting material. In view of the comprehensive character of these standards and of the possibility that requirements for further steels will be added to it from time to time, a system of numbering has been adopted which indicates each type of steel irrespective of its form. An appendix explains the system and indicates the basis on which it has been built. A helpful feature of the publication is its indication of the nearest equivalent American steel in either the A.S.T.M. or the A.I.S.I. series. In view of the need for special requirements for steels operating at low temperatures, a companion to this revision has been issued as B.S. 1510.

STEELS FOR USE IN THE CHEMICAL, PETROLEUM AND ALLIED INDUSTRIES (LOW TEMPERATURE SUPPLEMENTARY REQUIREMENTS TO B.S. 1501–1506)

No. 1510 : 1958. Price 4s. 6d. This new publication is a companion to the revised edition of B.S. 1501–1506, " Steels for Use in the Chemical, Petroleum and Allied Industries." It relates to eighteen steels for operation at low temperatures and to applications where a high degree of notch ductility is required. Special limits (other than those laid down in B.S. 1501–6) are specified for the chemical composition of three of the steels; and there are details regarding the selection and number of impact test pieces and the method of performing the impact tests —together with a list of the mechanical properties to be obtained.

RING GEAR STARTERS FOR INTERNAL COMBUSTION ENGINES

No. 3025 : 1958. Price 7s. 6d. This standard is designed to make possible the maximum degree of interchangeability of ring gear starters for internal combustion engines. It specifies envelope and attachment dimensions for electric, pneumatic, hydraulic and inertia starters for cradle and flange mounting, and makes provision for " inertia-engagement " and " pre-engagement " of pinions with ring gears.

Also specified in the new publication are certain data for starter pinions ; and there are recommendations for the ring gears with which they engage. Certain dimensions of the mounting flanges and the stub-tooth form for pinions and ring gears are based on current S.A.E. practice, which has been widely adopted in this country.

VOLTAGES FOR HIGH-VOLTAGE D.C. TRANSMISSION SYSTEMS

No. 3026 : 1958. Price 3s., excluding postage.—The projected cross-channel link between the French and the British power systems gives interest to this new publication. The specification provides a range of standard voltages for use in high-voltage direct-current transmission systems. It is appreciated that it is early in the development of the technique of high-voltage d.c. transmission to standardise voltages, but early standardisation is considered imperative to discourage the use of many different voltages for systems of similar character. The voltages listed in the standard include all those known to be in use at the time of publication.

WELDED AUSTENITIC STAINLESS STEEL TUBES FOR MECHANICAL, STRUCTURAL AND GENERAL ENGINEERING PURPOSES

No. 3014 : 1958. Price 4s. 6d. This standard specifies requirements for " as welded " and cold-drawn welded tubes manufactured from austenitic stainless steel strip welded across the abutting edges throughout their length. These tubes in the " as welded " condition are available in sizes from $\frac{1}{8}$in up to $2\frac{1}{2}$in outside diameter (in $\frac{1}{4}$in steps) and in thicknesses from 22 S.W.G. up to 12 S.W.G., depending on the diameter.

The standard contains a series of general requirements for test and inspection purposes. Specific requirements, such as delivery conditions and permissible variations in dimensions, are specified for each of the two classes of tube.

Research into Friction

On Friday last the new research laboratories of Ferodo Ltd., at Chapel-en-le-Frith, Stockport, were opened by H.R.H. Prince Philip, Duke of Edinburgh. The laboratories were opened to visitors during the subsequent week, and we were able to see some of the work in progress. Development testing of linings and brakes is performed on a number of inertia testing machines, one of which is seen here.

RESEARCH by Ferodo must be viewed against the background of progress which science and technology have made during the sixty-one years of the company's existence. The demands made upon brake linings have increased in number and intensity. Where at the beginning of the century, wear, friction and heat resistance were the only serious requirements, to these to-day are now added oil resistance, fade resistance, freedom from noise, water resistance, strength, " drum kindness " and bondability. To elaborate this list, a modern friction lining for automotive use must possess a stable coefficient of friction which remains constant during mountain descents, after immersion in a ford or standing out through a wet night. It must be durable, and avoid scoring or heat-spotting the metal surface of the brake drum. It should not smell after prolonged periods of hard work, nor should it groan or squeal. It must be strong enough to resist riveting, even when the rivet holes are extremely close to the lining edge, or, when the lining is to be bonded to the brake shoe, it must be compatible with the bonding adhesive. It must be capable of being made into hundreds, sometimes thousands, of sizes and shapes and in large quantities at reasonable cost. It must be capable of withstanding leakages of hydraulic brake fluid from the brake cylinders or oil from the back axle or grease from the wheel bearings. It must function satisfactorily in the winter cold of the Arctic and be capable of storage for months in the tropics without becoming brittle. Typical figures for the peak on the linings of a family car, measured in terms of brake horsepower per square inch of lining, were 0·3 in 1900, had advanced to 1 in 1910, 2·3 in 1930, and are now 5·2. Within the near future, with the introduction of a disc-braked family car, it can be expected to rise to the region of 9 b.h.p. per square inch.

Not only have these duties been increased because cars have become faster, with improved acceleration ; they have been further augmented by streamlining, which shrouds the brakes and thus takes them out of a cooling wind stream, and by the tendency for cars to have smaller wheels. The availability of friction materials able to withstand progressively more strenuous conditions has always kept pace with the demands of every advance in engineering design ; indeed the aim of these laboratories is to keep several steps ahead of them.

Their work is concerned in its basic aspects with answering two questions : (*a*) What is surface friction ? (*b*) what is the structure of the raw materials of which conventional friction materials are made ? On the development side it is, obviously, concerned with the evolution, production and evaluation of improved materials for existing and anticipated demands.

Fundamental Research

Surface Friction Experiments.—While knowledge of the physical and chemical processes which take place within materials is considerable, study of the surfaces of solids has been relatively limited. More is known about the particles and forces involved in the atom, about the atomic arrangement of the molecule, and about the molecular arrangement forming the solid, than is known about the effects arising at the boundary of the solid.

A group of physicists is, therefore, studying the nature of surface friction as an abstract problem. By examining the phenomenon of rubbing between various surfaces (for example glass and indium) which in themselves have no obvious connection with brakes, they hope to throw new light on the nature of rubbing friction between metallic and non-metallic surfaces. What happens at the contact area, and how is this changed under varying loads ? What temperatures are reached during sliding ? What are the relationships of associated phenomena, for example friction and wear, surface roughness and wear, surface roughness and friction ? How are wear particles formed, and what chemical and physical changes have they undergone ?

These are basic questions, and much of the original work in this field is being carried out in the Ferodo laboratories. Our illustrations show a machine for investigating the behaviour of a steel tyre under braking forces, and a much enlarged section through the surface of a metal specimen that has been rubbed. There was demonstrated to us a photo-elastic investigation of the parting in shear of two asperities that have welded together, a circular-section particle being liberated. Such work has already given some guidance on the materials required for particular friction and wear characteristics. It will be pursued in the years which lie ahead, for a fundamental understanding of all the factors involved in surface friction would virtually revolutionise the whole approach to brake lining manufacture.

Asbestos Structure.—The raw materials for conventional friction materials are asbestos, resin and certain modifying agents. Of these, asbestos is the most important. It was the decision, in 1908, to use woven asbestos, spun on brass wire to increase its strength, instead of a cotton fabric base, which proved to be the turning point in the company's early history. Asbestos in its long fibre form is spun and woven into cloth and is the basis of " woven " brake linings. In its short fibre form it is the basis of " moulded " linings.

White or chrysotile asbestos is by far the most important variety and comprises 80 to 90 per cent of the asbestos consumed in industry (its fibres impart strength to brake linings). It is a hydrated silicate of magnesium corresponding approximately to the formula $Mg_3Si_2O_5(OH)_4$. It is mined principally in Canada and Africa. In the crude rock form, the mineral usually has a dark green lustre, but, when opened, the fibres appear white. Individual chrysotile asbestos fibres are silky and very flexible with a diameter smaller than that of any synthetic fibre.

The reason for the fibrous character of other kinds of asbestos has been known for over twenty-five years—the atoms of which they are composed are joined together in long chain molecules, the chains running the length of the fibre : since there is little cross linking between chains, the material splits easily into fibres. Such information can be obtained by X-ray crystallography. Early attempts to apply this technique to investigating the arrangement of the atoms in chrysotile asbestos were either unsuccessful or gave only incomplete results.

Electron microscope photographs, which give a very high magnification, show that chrysotile fibres look like semi-transparent hollow tubes. Extensive work in the Ferodo

laboratories has now shown that the X-ray patterns produced by the fibres can be interpreted on the assumption that these hollow tubes consist of cylindrical layers of atoms stacked one inside the other. In the average fibre there are about ten such layers, the outermost layer being about one-millionth of an inch in diameter and the innermost layer rather less than half that.

Research into the structure of asbestos is conducted in parallel with other investigations of its properties. It is now known that there are various ways in which the successive layers may be stacked within one another when the fibres are formed, and the proportions of fibres with the different stacking arrangements are different in the asbestos from different mines. It is known also that there are various ways in which the layers may be rolled up, based on circular, helical and spiral cylinders. Evidence suggests that the hollow fibres are often "stuffed" with ribbons of the same structure. The X-ray method is also beginning to reveal the nature of some of the impurities in asbestos.

Up to a temperature of approximately 500 deg. Cent. chrysotile asbestos undergoes no physical or chemical change ; above that temperature it begins to lose its chemically combined water and gradually becomes brittle. It is, on the other hand, remarkably resistant to fusion and retains its fibrous nature at temperatures up to 1400 deg. Cent.

Chemistry.—Resins are used to bond together the constituents of a brake lining and give it the necessary physical properties. Basically the resins employed in friction materials are the phenol-formaldehyde type, which is thermosetting.

In resin chemistry precise analysis of the phenols available is fundamental. Hence the importance in this work of chromatography, which is applied to both liquids and gases, distinguishing the constituents by optical or ultra-violet illumination and ionisation respectively. The molecular structure of the constituents can be inferred from knowledge of their molecular weights (measured by their effects on the boiling point of a solvent) and from infra-red spectra, which suggest possible molecular structures for these different fractions which are consistent with their differing reactivities.

Deliberate variation of the resin formula and of the proportions of resin to other ingredients will affect the characteristics of the final product considerably. New synthetic resins must also be evolved with one eye on the complexities of large-scale factory production : for example, a resin with a critical cure time might be difficult to control under factory conditions.

The original method of making a resin involved distillation to remove water and was satisfactory for simple resins. Some new resins with improved properties were difficult to make in this way, since they thickened up so much that they cured before the water was removed. This difficulty was overcome by dissolving the resin in a solvent, which distils with the water, but separates and returns to the resin.

Another chemical investigation which was shown to us was intended to suppress the tendency for clutches to be stuck solid by rust after standing in the open for some time. Sodium nitrite had been found to inhibit corrosion of the faces in contact with the friction lining for about 10,000 miles, after which the effect is reported less frequently.

The Ferodo Test House

After a new experimental lining has been processed, it is most important that it should be tested under conditions closely simulating those it will encounter in service. For example, in developing a lining for racing purposes, high rubbing speeds must be used ; the duties to be simulated for private cars, trucks, buses, aircraft and industrial applications generally differ considerably from each other. Since it is not practicable nor necessarily desirable to test all experimental linings on the road, test machines are employed. They are not only used as a filter to reject for road testing materials that do not show considerable promise, but possess the advantage that the conditions of test can be strictly controlled.

Machine-testing speeds development by eliminating many time-wasting factors. Cooling can be accelerated by fans, so that more brake applications can be made in a given time without over-heating the brakes. Automatic controls enable the machines to work day and night without the need for a large team of drivers.

The machines used are inertia test dynamometers so proportioned that a complete brake can be mounted for test. They consist basically of a driving motor, coupled to a shaft carrying a bank of flywheels. The brake drum is mounted on one end of the shaft, while the brake back plate and shoe assembly is attached to a torque reaction member mounted in line with the shaft, the torque loads imposed on it being indicated and/or recorded. The brake reaction shaft is mounted so that it can slide back to allow the brake to be withdrawn from the drum for examination.

One flywheel is keyed to the shaft and thus always revolves with the brake drum. All the other flywheels are mounted on bearings on the shaft and may remain stationary when the shaft revolves or be coupled to the fixed wheel. By coupling different numbers of flywheels the inertia of the machine can be adjusted to give approximately the inertia to simulate, at the appropriate shaft speed, the conditions obtained on the vehicle.

In a test the flywheels are accelerated by the driving motor until the brake drum reaches a speed corresponding to the desired road speed of the vehicle. Then the motor is declutched or shut down and the brake applied to bring the machine to a standstill. A complete test will consist of groups of between thirty and 100 such stops, with cooling periods between the groups.

In the test house there are a number of these inertia test dynamometers, and the house is designed to accommodate future expansion should that prove necessary in the future. The larger machines are engaged on aircraft, heavy transport, railway and industrial brakes ; the smaller on development for cars, motor-cycles and pedal cycles. They are not merely employed to evaluate new formulations : a check is also kept on factory production, and facilities are also available for testing brakes themselves, as distinct from linings, on behalf of manufacturers. Our heading illustration shows an A.M.C. front brake being offered up for test: notice that long, narrow linings are used in a full-width hub.

A typical control panel can operate a machine automatically at a number of speeds, time cycles, braking torques, cooling settings and times, all preselected over a sequence of 2500 brakings. The latest panels are fitted with a triple dekatron counter which automatically indicates braking times up to ten seconds to the nearest 1/100th second, relieving the operator of stop watch tripping and making for greater accuracy.

Such apparatus is designed and built by an electronics section, working closely with a machine control section, both under the test house manager. The former also makes and fits the thermocouples which measure the working temperatures of brake linings on test machines and vehicles. Infra-red detectors employing lead sulphide have been applied which have so short a time constant that they can detect heat spotting on a drum while it is revolving at high speed.

The machines can be divided into constant torque and constant pressure inertia machines. Automatic constant torque inertia machines test lining material under standard conditions. It may happen that when a brake is applied, the heat and pressure generated on the surface of the lining cause the coefficient of friction to vary during the stop, usually to a lower value. This class of machine automatically adjusts the pressure to compensate for any fluctuation in friction coefficient ; any self-servo effect from the brake shoe is also compensated. Thus, linings are tested at equal rates of energy dissipation, and all materials on the same test reach the same temperature, which is particularly desirable for comparison purposes.

The constant pressure machines cover four inertia ranges. They normally operate at constant pressure applied to the lining, but owing to the variation in friction coefficient

Photomicrograph of rubbed metal surface obtained during fundamental investigation on friction. Horizontal magnification × 360 : vertical magnification × 2000

and self-servo pressure, the brake torque is not constant. When automatic torque control is required, however, this can be selected on one of the small inertia machines.

A complete cycle of machine tests on a brake lining may reveal certain faults, for example, variation in the coefficient of friction during each individual brake application, reduced friction level after fade, effect of temperature upon friction, undesirable speed/friction characteristics, inadequate resistance to moderate or severe fade conditions, severe over-recovery from fade, or delayed fade. The wear of the brake lining can be assessed either on the basis of the weight loss or by the reduction in thickness during the test, as measured by a micrometer.

Clutch facings are tested on machines which simulate both normal engagement and slip at full torque. The former class consists of two flywheels mounted on a common shaft to which two standard 10in clutches are bolted. A motor drives the spinner of one clutch while that of the other is held fixed to the frame. The twelve-second cycle, which is auto-controlled, consists of spinning the assembly up to motor speed by engaging the first clutch. This is then released and the second let in to brake the assembly to rest. Apart from a small amount of energy absorbed by the bearings, the two clutches do the same amount of work, one by acceleration and the other by braking. From this test the wear of a facing after 10,000 cycles is obtained. The friction of the facings is also measured at intervals throughout the test.

The slip test machine consists simply of a motor driving a standard flywheel assembly. The motor is run with the clutch fully engaged and the spinner held fixed by a dynamometer. As the clutch spring pressure is calibrated before each test, the torque, which is recorded, is a measure of friction coefficient.

A clutch bursting machine determines the rotational speed at which centrifugal forces cause a disc facing to fly apart at clutch housing temperatures. The disc, clipped to a face plate, is mounted on a shaft inside a safety chamber which is heated to a controlled temperature. The shaft is spun by a variable speed motor and step-up drive and can reach some 25,000 r.p.m. Usually, however, discs disintegrate before 19,000 r.p.m.

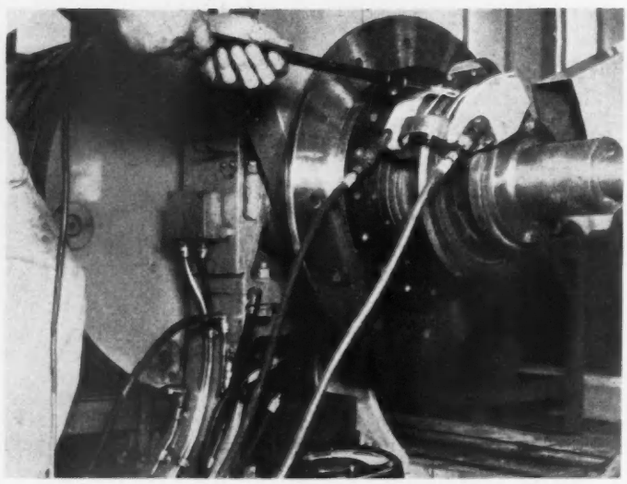
Tests on Vehicles

A lining that has successfully run the gauntlet of the test machines is then tried out on a vehicle in the Ferodo test fleet, since its road characteristics can only be evaluated during use in a normal manner over considerable mileages. The fleet of test vehicles—motor-cycles, large and small saloon cars, high performance sports cars, lorries and buses—provides a range sufficient to cover all types of private and commercial vehicles. They are all fitted with instruments, making them in effect mobile laboratories. Some instruments record braking pressures; others decelerations during brake tests; electric devices register the brake lining temperature and the number and duration of brake applications. For every kind of vehicle there is an appropriate daily test circuit in the Peak District or the neighbouring Cheshire plains, mapped out to reproduce typical operating conditions.

A particularly demanding application is the double-decker bus, but it is not possible to operate these vehicles in the vicinity of the works, so that linings for public service vehicles have to be tested on a special vehicle. This is a Daimler single-deck bus, on a double-decker chassis, loaded with weights to simulate a full passenger load on a double-decker. Two large trap doors are set in the floor to allow inspection of brakes and braking system, and to permit fitting of thermocouples. These are embedded in the linings under test and are connected with a bank of thermocouple meters which can conveniently be read by an observer seated in the passenger compartment. Thermocouples on the rear drums are connected through slip ring units, held against rotation by gravity, on the ends of the hubs. Other instruments include pendulum and U-tube decelerometers, air-line pressure gauge, and an electronic system for controlling the frequency of stopping. This device, known as the "ghost conductor," is preset to give a cycle of buzzer signals to the driver. On the first buzz, the driver takes off his brakes and accelerates; on the second, he brakes to a stop in neutral; on the third he starts again, and so on. Other automatic devices on board measure the number of brake applications, the total time during which the brakes have been applied, and the total time during which the vehicle is stopped.

Performance Tests.—Performance tests observe the relationship between the pedal load exerted by the driver and the resulting deceleration. They are conducted on a level stretch of road, a series of stops being made from a fixed initial speed at suitable increments of pedal load, as read from a pressure gauge connected into the brake pipeline. Decelerations are normally read from a Tapley decelerometer. The brakes are given adequate time for cooling between brake applications, so that the temperatures to which the linings are subjected are kept moderately low.

Speed/Friction Tests.—On a level stretch of road the vehicle is accelerated to a relatively low speed, the brakes are applied at a predetermined pedal effort, with the gears neutral, and the deceleration noted. The test is then repeated from progressively increasing speeds up to speeds near the maximum speed of the vehicle. Throughout these tests the brakes are kept relatively cool.



The temperature of a fixed-caliper single-disc brake being measured after a simulated stop

Fade and Recovery Tests.—Fade tests may be carried out on the company's own 700-yard-long test track, which was converted eighteen months ago from the old Peak Forest tramway, which used to carry limestone from Dove Holes, near Buxton, to the Peak Forest Canal Wharf 7 miles away, near Buxworth. The track begins only 200 yards from the Research Centre.

The fade test raises the temperature of the brake drum rapidly to a high temperature, the behaviour of the brakes being observed during the process. Temperatures equal or exceed the highest ever reached in service. In the test a vehicle is accelerated to a relatively high speed and is then braked to a standstill at a predetermined deceleration, the pedal effort required to produce this deceleration being noted by an observer. The whole process is repeated on a time cycle with little time between successive applications. In a typical fade test studying the effects of repeated hard braking on a steep hill, the pedal effort is recorded in a series of fifty stops at one-minute intervals from 50 m.p.h. (or higher for sports cars) with a constant $\frac{1}{2}$ g deceleration.

On a heavy vehicle it is difficult, if not impossible, to put the required amount of energy for a fade test through the brake by accelerating and braking on a level road. The test is, therefore, conducted on a hill descent, the brakes being applied at predetermined points to bring the vehicle to a standstill, the energy of the descent adding to the normal kinetic energy absorbed in stopping the vehicle.

After a fade test it is normal to determine the "recovery" of the lining, checking the behaviour of the lining during the cooling process. Further brake applications are made and measurements taken. To avoid interfering with the cooling process as far as possible, the brake applications are normally made from a reduced speed, so that only a small amount of energy is transmuted through the brakes.

Water Recovery Tests.—Most vehicles need a braking performance that remains reasonably constant even after immersion of the brakes in water. Water in the drum tends to provide a lubricating action, resulting in temporarily lowered friction. This should not last long, and normal frictional behaviour should be smoothly resumed without any temporary high friction. To check the behaviour in these circumstances, the vehicle is made to do a succession of stops from low speed on a level road after several minutes' immersion in water, and the deceleration for a normal pedal effort is observed. The recovery of the lining from its immersion in water can then be assessed by the sequence of deceleration readings obtained.

Speedometer Calibration.—In all the tests described above it would not be possible to compare results unless the vehicle's speed were accurately known. Hence it is vital to calibrate speedometers accurately. The apparatus used for the purpose consists of an electric chronograph started and stopped at the approximate times by pulses from a photocell mounted concentrically with a light source. The latter unit is clamped to the vehicle bumper so that the light from it falls on the road and is reflected in sequence by two mirrors which are placed face upwards on the ground at a known distance apart and normal to the light beam. The reflected light thus falls upon the photocell, and the two electrical pulses so obtained are used to stop and start the chronograph.

(Left) A rail/tyre adhesion measurement machine : on this a small brake block is pressed against the right-hand wheel (which represents a railway wheel) at increasing pressure until slip begins to occur between it and the large wheel which represents a rail. The friction forces arising during this process are indicated on continuous recording charts and the amount of slip can be measured from the differential in the foreground. (Right) A "C" series Vincent fitted with an accelerometer, or, more correctly, *g*-meter for brake testing. The instrument reads 0.78 *g*

The mirrors are mounted on wooden blocks and are marked so that the effective width in the direction of motion is ½in. The blocks are placed on the road opposite accurately measured marks 40ft apart. The mirrors are 15in long and it is easy, by watching a white guide line in the centre of the road, to drive so that they pass centrally between the wheels, the lamp unit being mounted on the centre of the rear bumper. This equipment has been used to check speedometers at speeds from 10 to 60 m.p.h.

Friction Materials for Disc Brakes

Originally developed for aviation braking, the disc brake is now fitted to several high performance production cars and to buses of the "Midland Red" fleet. It is being introduced into the commercial vehicle field, and is being tested by British Railways for railway braking. The disc brake, which calls for friction materials not in arc-shape linings but in flat disc segments, owes very much to the development of friction materials capable of withstanding extreme pressures and temperatures, and we understand that nearly all British production vehicles equipped with disc brakes fit Ferodo friction pads as initial equipment.

Disc brake friction materials are of the moulded type. Because disc brakes are normally fitted where braking duty is unusually severe, the material must be unusually resistant to fade. There must be no risk of surface cracking due to the temperatures generated during braking, and the material must possess considerable mechanical strength for a duty which is the equivalent of 9 or more b.h.p. per square inch of lining—nearly twice as heavy as the duty expected of a drum brake lining. Fortunately, a material which does not have to be bent in manufacture makes less stringent demands on the organic bonding agent, with the result that materials with greater heat resistance can be employed.

Development of disc brake materials follows the same pattern as that of moulded materials for drum brakes, with obvious variations. For example, one of the test machines in the test house is specially designed to accept various types of disc brakes on the flywheel shaft, and some of the faster test vehicles are disc braked. Our illustration shows the temperature of such a brake being measured after a test on the machine. Since it is predictable that disc brakes will appear on cars in quantity production before long, this work will inevitably bulk still larger in the Ferodo research schedule in the next few years.

Powder Metallurgy Techniques for Friction Materials

Until recently conventional friction materials, based on asbestos, fulfilled all the demands made upon them for the control and transmission of power. Much modern earth-moving equipment, however, depends on clutches which must sustain duties beyond the scope of conventional linings and facings, and a similar problem faces the designers of tractor clutches, automatic gearboxes for road and rail vehicles, and lock-up clutches for the torque convertors used in railcar propulsion. Alternative materials are required capable of retaining their strength and performance at the high temperatures produced in heavy-duty applications.

Cast or wrought metals have the requisite strength, but have quite unsuitable friction and wear properties. A solution to the problem has been found in composite materials produced by powder metallurgy. Sintered friction linings, as they are called, consist of mineral fillers distributed throughout a metallic matrix. The component powders are mixed conventionally and compacted to a handleable form in high tonnage presses. Since the friction facings are often large and thin, accurate dispensing of the mixed powders into the die (or mould) cavity is extremely important. Compacted density is controlled by the shape, size and apparent density of individual powders. Increase in density and bonding to a supporting member is effected by pressure sintering at red heat, a reducing atmosphere being maintained around the parts during sintering to assist in densification and bonding.

Sintering may be defined as the bonding together of metallic particles at a temperature lower than their melting point. The driving force in sintering is surface tension, the principal mode of material transport being viscous flow. The area of contact between particles grows as the sintering time is extended, and voids or "pores" between particles are removed during the densification process.

Research on sintered metal linings is concerned both with components and with their processing. It begins with the analysis of particle size distribution, which is conducted by the Ro-tap sieve method, sedimentation balance weighing and microscopic counting, in which representative samples of powder are compared directly with special eyepiece graticules. At the same time, another group is at work on improved methods of compacting, handling and sintering the powders. For example, the radius forming of sintered friction materials is an important field of development at present.

Since these linings were described in The Engineer (page 630, April 25, 1958), techniques of bending the lining have been evolved, but the method used when the sinter is outside, i.e. in tension, is at present undisclosed.

We understand that experience with the Ferodo sintered materials, which were initiated by the S. K. Wellman Company, has shown that, compared to asbestos-base materials, life may be multiplied five times, while the cost increases 150 per cent : although friction materials are acknowledged to be expensive, this improvement is attractive when the cost of installing the linings is taken into account.

Cerametallic Materials.—The introduction

of a metallic phase into a ceramic body improves its ease of fabrication and mechanical properties. Compared with sintered metal linings, cerametallic friction materials have increased heat and wear resistance and a higher friction level. Research work on cerametallics is being directed principally to improved methods of fabrication. The basic method of manufacture is to mill the component metal and ceramic powder and to compact and sinter them at high temperature.

Building Design and Construction

The building occupies a hillside site to the north of the main factory buildings, sloping down eastwards to its frontage. On the upper part of the site sandstone occurs near to the surface, but falls to some 20ft below at the lower end.

All structural foundations, including main underfloor ducts and machine beds, are taken down to the rock, in the deeper parts by a system of reinforced concrete piers and beams. The main incoming underground service duct from the works, which crosses a subsidiary infilled valley, is a reinforced concrete box beam spanning between concrete piers at 25ft intervals. The use of " designed mix " concrete to give a maximum density has obviated the necessity of other waterproofing measures to underground ducts.

All parts of the building are framed in structural steelwork. The test house and experimental production wings have a clear floor span of 75ft with facilities for overall crane coverage. Here welded lattice girders support " monitor " roofs, which, in combination with the side windows, give four-directional natural light. Asbestos cement cavity decking is used for the roof of these wings, and the upper portion of the walls is in " Colorglazed " combined asbestos sheeting. Continuous gutters and parapet run past the end of the " monitors " to give safe access to all parts of the roof.

In the administration and laboratory sections (two, three and part four-storey) the steel framework is on a 10ft grid, and the external walls are generally of cavity brickwork with continuous windows. The internal partitions are in timber-framed, demountable standard units to allow easy rearrangement, and the division of the structural grid by window mullions allows flexibility on a 5ft module. Suspended floors are formed of *in situ* reinforced concrete, with hardwood finishes, and embedded ceiling heating coils.

In the laboratories the timber floor is independently supported above the structural concrete to accommodate drainage channels and engineering services with full flexibility. The supporting timber in this floor, and all timber elsewhere when subject to possible rot, is pressure impregnated with Wolman Tanalith.

Climatic conditions are severe, and particular regard has been given to thermal insulation by the use of double glass and internal application of Limpet Asbestos Spray to all asbestos cladding and roof decking. The latter is also covered with insulation board, and 2in cork is used on concrete roofs.

The possibility of excessive loading by snow has also been taken into account. In the High Peak a 10ft drift snow load between monitors would not be unusual, and has been allowed for in the roof construction.

The Limpet Asbestos Spray in the test house and experimental production wings has a second function of sound absorption, and Newalls' paxtiles are also used in certain offices for the same purpose.

The test house and the experimental production laboratory are heated by high-level unit heaters controlled by thermostats fixed at working level. Ventilation is by means of fresh air ducts connected to the unit heaters and by separate extraction fans in the roof. The installation is designed to maintain a temperature of 65 deg. Fah. in the buildings with an outside temperature of 25 deg. Fah.

The laboratories and offices are heated by the invisible panel system using jointless coils of special steel tubes embedded in the ceilings of the rooms. Warmed water circulates through the tubes, raising the temperature of the ceilings to slightly below " blood heat " and providing low temperature radiation to the occupants of the rooms. This radiant heat is supplemented by convected heat from a balanced plenum system ventilating plant which supplies filtered and warmed fresh air to the various rooms, the air then being positively extracted from the building by a fan. The installation is designed to maintain a temperature of 65 deg. Fah. in the rooms with an outside temperature of 20 deg. Fah.

A single-deck bus loaded to simulate a double-deck vehicle is used to evaluate p.s.v. brake materials

Steam at 180 lb and 40 lb per square inch is supplied from the main works boiler-house, the whole of the condensate being returned to the boiler-house. Duplicate air compressors are sited in the test house and compressed air at 100 lb per square inch is taken to machines and laboratory benches. Hot and cold water services and automatic sprinklers are provided throughout the buildings, and fire hydrants are installed.

Two electric automatic push-button controlled 1-ton goods lifts are installed, each with a two-speed motor for accurate levelling.

The electricity supply for the new buildings is looped in and out from the existing factory 11kV ring main. The substation has two outdoor 750kVA transformers controlled on the high voltage side by oil-immersed ring main units and on the medium voltage side by air-break cubicle type circuit breakers, the busbars of which are connected to unit type metal-clad switches and H.R.C. fuses for the main 400V distribution system. Sub-main switchboards, again of the unit metal-clad type, are situated in the test house and experimental production laboratory. From these switchboards sub-mains and large machine circuits are taken away by M.I.C.C. cables on perforated trays. Fuse distribution boards for the smaller circuits are fitted with energy limiting cartridge fuse links. An emergency supply of up to 400kVA from the works diesel generating plant is available at the substation medium voltage switchboard, Castell interlocks being provided.

General lighting is provided in the test house and the experimental production laboratory from blended lighting units mounted at roof-truss level. Each unit contains a 250W mercury vapour lamp and a 500W tungsten filament lamp. The installation is group controlled from conveniently placed push-button contactors and provides an overall value of illumination of about 18 lumens per square foot on the working plane : 80W fluorescent tubes in ceiling-mounted fittings provide the lighting in the laboratories and offices, giving an average value of illumination of about 30 lumens per square foot at desk level. Combined patrol and emergency lighting is provided throughout the building. This is automatically maintained in the event of failure of mains supply on either side of the substation medium voltage switchboard.

The mains for all services are brought from the existing buildings through a " walkway " covered duct beneath ground level. The duct is continued beneath the floors of the test house and the experimental production laboratory, and branches from the mains are taken away in shallow trenches to the various pieces of equipment.

In the laboratories, branches and sub-circuits of all services are housed in specially made timber ducts running along the walls from window-sill level to floor level. Services to island benches are accommodated in the sub-floor.

Dust and fume extraction equipment is installed to serve the laboratories and experimental production laboratory.

Architect, Consulting Engineer and Contractors.—The architects for the new Ferodo Research Laboratories were Messrs. Ashworth and Fletcher: the quantity surveyors, Worrell and Kelly : the consulting engineers, R. W. Gregory and Partners : and the main contractors: building and civil engineering, J. Gerrard and Sons, Ltd; structural steelwork, J. Booth and Sons (Bolton), Ltd. ; electrical, E. M. Evans and Sons, Ltd. ; heating and ventilating, G. N. Haden and Sons, Ltd. ; sprinkler installation, Atlas Sprinkler Company, Ltd.

Fuel Pump for Quantity Production Diesels

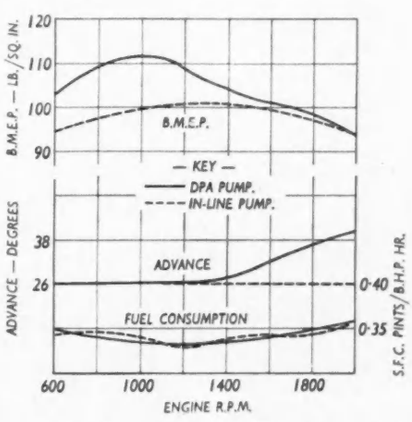
In the two years since C.A.V., Ltd., in this country, initiated production of a distributor pump for oil engines it has been applied, experimentally or otherwise, to a large number of engines: thus it is now possible to amplify the description published on September 14, 1956 (*page* 373). *It appears that the pump may not only reduce the initial cost, but also extend the performance limits of high-speed engines. The driving torque is relatively low and does not change its direction cyclically, so that a skew gear drive, as used on the Land-Rover seen here, is practicable.*

FUEL injection pumps with a single pumping element and a distributor to adapt them to multi-cylinder engines were first studied by C.A.V. with the intention of extending the application of the oil engine to fields in which first cost was critical, and from which it was disqualified largely by the high cost of the fuel injection equipment.

Development of distributor pumps took place over several years, but early in 1953 it was decided to review the work done both by C.A.V. and others, in order to determine future policy. Attention was drawn to the distributor pump then under development by the Hartford Machine Screw Company in America, which operated under entirely new principles. Examination of this design showed it to be extremely attractive, first because it was basically simple and could therefore be made at low cost ; secondly, the design was such that high speeds could be attained without mechanical complication ; thirdly, the principles of operation were such that timing variations necessary to successful operation over wide speed ranges could readily be provided automatically at little extra cost ; and fourthly, the drive requirements for the pump were simple and offered considerable scope for cost reductions in the necessary provisions to be made on the engine as well as in the pump itself. In addition, this distributor type pump had already undergone a number of years' development, and was by no means an untried piece of equipment. It had been used extensively on a wide variety of engines with eminent success.

An agreement was concluded by C.A.V. for the production and further development of this design, and an intensive effort was directed on the development of the pump, known as the " D.P.A. " type, to meet the requirements of British and European engine designers particularly. No attempt was made to maintain interchangeability with the " Roosa Master " pump, since the requirements of United States engine manufacturers differed so markedly in both specification and quantity that C.A.V. did not intend to meet them. The developed pump is significantly different, particularly in that it incorporates unloading by means of a retraction ramp separated from the injection face of the cam ring by a small radius : this unloading facility is particularly important because C.A.V. have evolved a technique of deriving excess fuel for starting from pumps incorporating it. It is known that starting is facilitated by retarding injection—selection of excess fuel on the normal camshaft pump is beneficial largely because of the resulting delayed cut-off—and by suitably positioning the delivery ports of the rotary pump they can be caused to close immediately injection ends when the pump is retarded for starting. Closing the delivery ports prevents unloading and therefore increases the actual quantity injected : for injection systems of normal proportions, the pressure energy available at the pump output port at the end of injection is large enough for unloading a volume comparable to the actual delivery, and 50 per cent excess can be achieved by suppressing unloading in this manner.

This retard of timing for starting can be obtained either by manual selection—closing a cock admitting oil to the automatic advance mechanism—or automatically : in the event of retard being selected manually and not discarded, the operator will be warned of his error by lack of power and/or excess smoke.

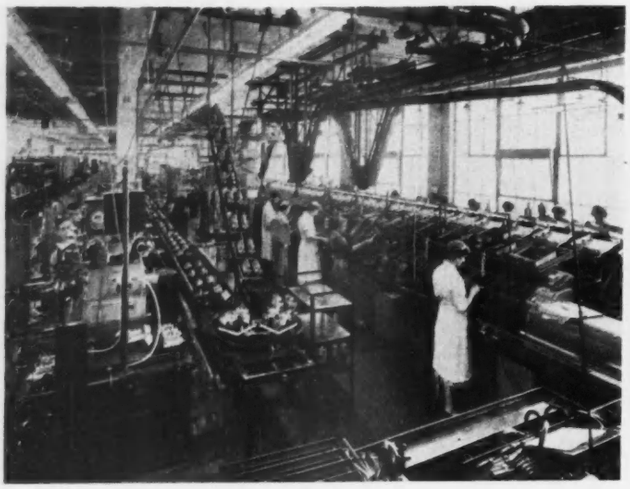


The ability to match the combustion characteristics is here applied to an 11-litre direct injection engine: the rate of injection has been reduced with the distributor pump

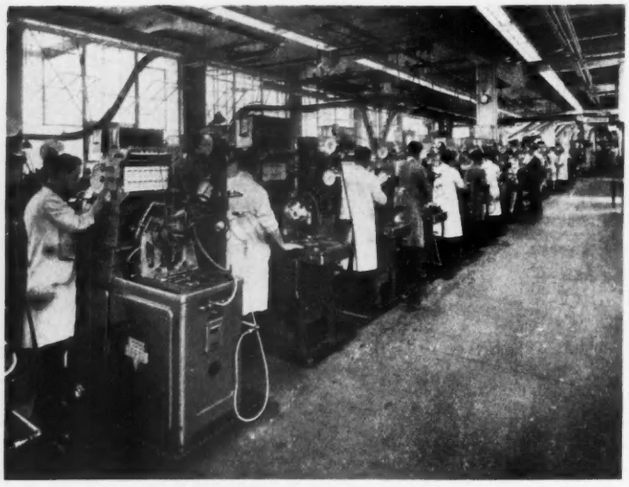
The variation of timing with load of the distributor pump is basically that of an inverted helix jerk pump, i.e. retard at light load. It is largely for this reason that the idling of engines with the " D.P.A. " pump tends to be both quiet and steady. However, when load is low at high speeds, as when the governor is in action, retarded injection is undesirable and liable to cause misfiring. The ideal timing can be approached with this pump by means of light load advance : one way of obtaining this is by feeding the advance mechanism, not with transfer pressure, which gives virtually pure speed advance, but with transfer pressure modulated by the movement of the metering valve so as to increase as the metering pressure is reduced. Another way is by incorporating in the automatic advance a light spring which will deflect under the torque imposed on the cam ring by the followers : the cam ring will then be retarded with increasing load. This latter technique is used in the pumps for the Perkins " Four 99 " engines, and has suppressed the tendency to emit black smoke from the exhaust when running fast against the governor.

This particular application, which is a particularly high-speed one (the highest rating is 43 h.p. at 4000 r.p.m.) is of interest since the performance was found to be unattainable with a camshaft pump, largely because of the need for injection advance at high speeds. The cam form evolved employs a double slope, gradual at first and steepening later. The hydraulic governor has now been modified to perform satisfactorily with an engine of such wide speed range, an additional spring which contacts the metering valve when it is near the idling fuel setting having been incorporated to prevent the valve closing so far under " reduce speed " error signals. (The performance of the governor on the " Four 99 " was described on page 669, May 2, 1958.)

Another respect in which the " D.P.A. " pump can extend the performance of the



The assembly line was laid down to handle about 1000 units a day. In the foreground is a tank for observing leaks from pumps pressurised with air



One of two banks of test benches for handling production pumps: a typical acceptance level is a calibration error of 0·8 c.c. in 10 c.c.

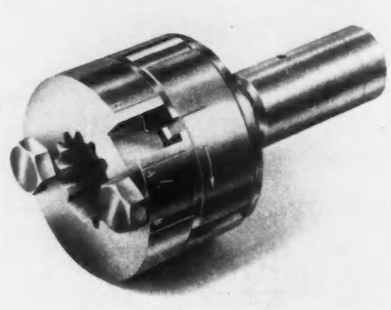
engine is by matching the torque curve more closely to the limitations of the engine. The delivery characteristic of the pump at full plunger travel tends to rise slightly through the bottom of the speed range, up to, say, 800 pump r.p.m., due to leakage, and then continue more or less constant. The plunger travel achieved tends to decrease with speed due to pressure losses in the passages, and this tendency can be modified by varying the transfer pressure by the design of the regulating valve. Transfer pressure normally runs up to about 100 lb per square inch before the maximum speed governor acts: the pump speed is correspondingly limited, at present, to around 12,000 injections per minute, while it is expected that this limit will be raised to 15,000 in the future. Thus it is easier to obtain a negative gradient on the torque curve than with a camshaft pump, where the output characteristic is varied by changing the configuration of the delivery and unloading valves or the geometry of the rack stop. An example of the effect of this is shown in our graph for an engine which was, with the in-line pump, limited by smoke at high speed: for the same peak power an improvement in maximum torque of over 10 per cent has been obtained.

This example is worthy of study, since the Bosch-type pump for a six-cylinder engine such as this would be markedly more expensive than the distributor pump. Comparison of the two sets of results is not easy: for instance, the curves of advance relate to the commencement of pumping, and the actual injection at the nozzle may be delayed longer in the in-line installation than with the "D.P.A." The variable timing feature has been employed to allow a much lower rate of injection, spread over more than 20 deg., and has resulted in a significantly better low speed performance. It can be seen that the output from the distributor pump is close to constant above the maximum torque speed, the torque and consumption curves having corresponding gradients. The delivery will, of course, be affected by change of unloading with advance, and the characteristic at constant timing is probably similar in shape to that of the in-line pump. If desired, pumps with mechanical governors can be supplied with a "torque screw" to alter the open attitude of the metering valve and hence the rate at which plunger travel drops with speed.

While the hydraulic governor has as its main advantage simplicity and cheapness, the mechanical governor, being required to exercise very little effort upon the metering valve, has a performance such as is normally associated with true servo systems. Figures recently released claim run-up from maximum to zero torque varying between 3·8 and 2·6 per cent: the amount of run-up does not reduce with speed in the range covered, 1200 to 2000 r.p.m. (For the hydraulic governor, run-up is 8 to 10 per cent.)

At present, neither temperature nor altitude compensation is available, but the latter may be offered in the future. The pump is not cleared for operation on petrol, but development towards the "omnivorous" ideal is being attempted. The range of plunger bores is from 4·5mm to 10mm in 0·5mm increments, and of strokes up to 2·2mm: the maximum output recommended is 100 cubic millimetres per stroke. We understand that a larger version is envisaged, although the present pump should be capable of replacing "B" size in-line pumps.

It will have been realised that most of the design variables by which a pump is suited to an individual engine are, on this pump, settled when the pump is made, and parts such as the cam ring will be special to particular engines. Thus the pump is regarded as most suitable for engines produced in large numbers. Its first application, in the case of the "D.P.A.," was to the Standard "23 C.V." in the Rootes light diesel truck and "23 C" in the Massey Ferguson tractor (see page 479, October 5, 1956). The six-cylinder version also first appeared on a Rootes commercial vehicle, being fitted to the Perkins "C.305." The four-cylinder version also is used on Perkins engines, the "Four-99," (page 754, November 22, 1957) unlike the above-mentioned engines, having been developed from the start to use it. No two-stroke engines have yet been fitted with it, but it has been disclosed that a three-cylinder version has been made by continuing the delivery port of a six-cylinder pump across the whole diameter of the rotor, and this could clearly be used on the Rootes diesel if driven at half engine speed.



The rotor assembly: clamped between the drive plate and the rotor is the disc carrying the plunger travel stops. Eight divisions, A to H, are for use in timing: one will show delivery port opening

Pump Production

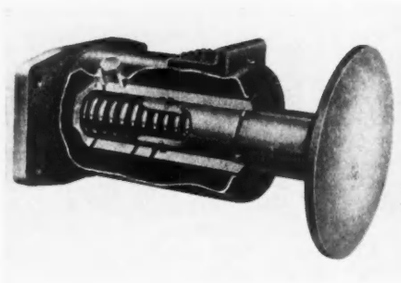
Since the primary reason for taking up the Hartford pump was to reduce the cost to engine builders of fuel injection equipment, and thereby allow mass markets for engines to be entered, C.A.V. planned the manufacturing facilities to produce very large numbers of pumps at a cost too low to admit any competition. Production is at present 32,000 units a month, which is the same as the number of individual elements in camshaft pumps leaving the Rochester works. We recently visited the factory, and observed that the bulk of the labour is of a low grade of skill, often female. Drilling is frequently to close standards, since, as has been indicated above, the phase relationship of ports is critical. For the high-pressure components, mensuration is generally in microns, with plungers being graded in $\frac{1}{2}\mu$ sizes and assembled selectively to give $2\frac{1}{2}\mu$ to 3μ clearance. Working bores are finished on Micromatic automatic hones, checked by air gauges. The cam rings are profiled with a broad wheel on a copying plunge grinder, and subsequently checked for profile on an O.M.T. optical pantograph: concentricity is measured by a micrometer from the outside circumference, and radial location and parallelism with the axis by inserting a tapered mandrel in both directions.

The pumps are assembled on a conveyor, all screws being tightened with torque wrenches. It is then submerged in oil and filled with compressed air to test for leaks (the pump runs full of oil under pressure, so that failure of the seal surrounding the drive hub may cause an engine to run away). Each pump is then tested on a Hartridge test bench: the maximum plunger travel stops, regulating delivery at the lower speed end, can be adjusted after removing an access cover, on the mechanical governor pumps, or the back leakage pipe adapter. In our illustration, the plate carrying the helical travel stops can be seen, together with its setting reference and the notch to move it by. The control stops are accessible on the outside of the unit, and they also are set on the test bench: pumps can, if required, be supplied to need no adjustment after installation.

Automatic Coupler and Hydraulic Buffer Testing Site

A specially equipped test site has been laid down by Dowty Hydraulic Units, Ltd., to simulate all types of working conditions which the firm's automatic coupling and buffing gear for railway vehicles are likely to encounter in service. In addition to the test tracks there have also been developed a number of test rigs for simulating both normal and extreme working conditions to ascertain the efficiency, potential life, and strength of buffers and couplers.

TO provide facilities for the further development and the testing of railway wagon buffers and couplers now being made by Dowty Hydraulic Units, Ltd., the company has installed at its Ashchurch Works, near Tewkesbury, a special rail track testing site and introduced a number of service simulating testing equipments. The buffers and the couplers are both relatively recent developments of the firm, and as they have not been



Hydraulic buffer with section cut out to show construction

previously described in our columns some notes on their design will be of interest before dealing with the new testing facilities.

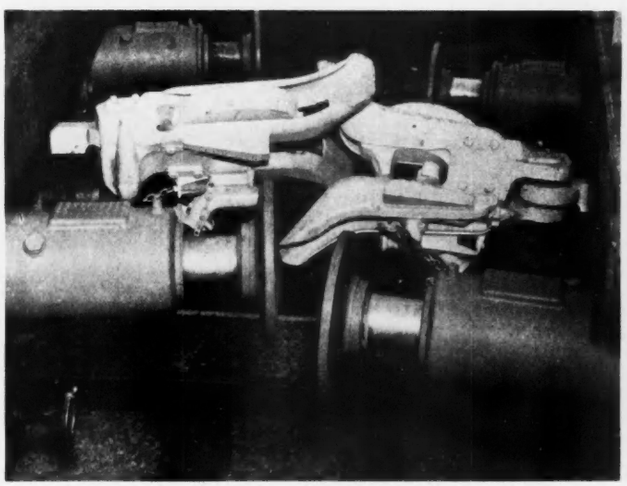
The hydraulic buffer, which is shown in section in one of the illustrations on this page, consists essentially of a combined reservoir and cylinder housing a piston loaded in the extended position by a helical spring. On impact, the inwards movement of the piston displaces the fluid in the cylinder behind it into the surrounding reservoir through orifices in the cylinder wall. As the piston moves back it reduces the orifice areas and the restriction imposed on the oil flow causes a back pressure which reacts on the piston, giving the buffer its resistance to closure. The pressure generated in the buffer is directly proportional to the energy to be absorbed and the buffer is self-adjusting to change in impact energy resulting from variations in wagon velocity.

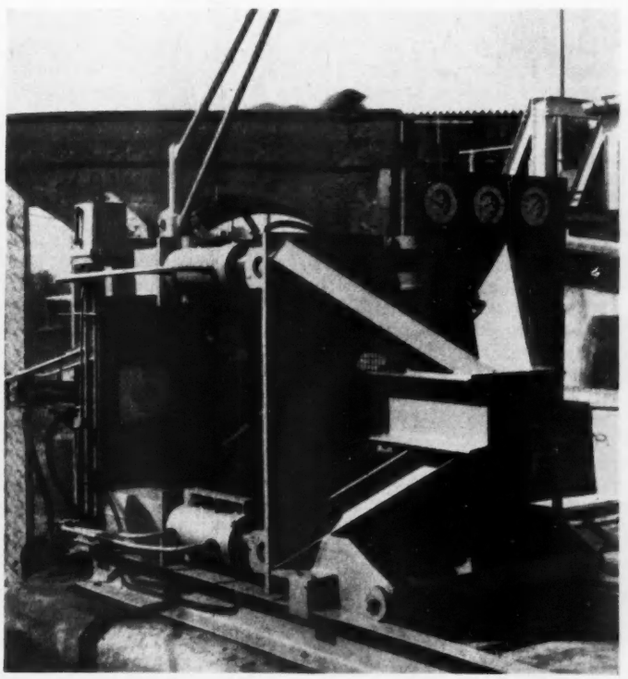
Impact energy is converted into heat energy as the buffer closes and the small quantity of air trapped in the buffer is compressed slightly as displaced fluid raises the level in the reservoir. On completion of a rearwards stroke of the piston, the bulk of the impact energy has been dissipated, and a controlled recoil results from the combined effects of the load imparted by the recoil spring and the air pressure.

Our second illustration shows a pair of the firm's automatic couplers approaching the position of engagement; in this case they are fitted to wagons of different height and being brought together on a sharp curve. These couplers have large gathering horns which align their hooks and the brake pipe connections as contact is made. The hooks are pivoted in their mountings and as they complete their engagement their forward faces contact pivoted locking pawls at the rear of the assembly. Each pawl swings over to engage a hook on its end with a step on the entering coupling hook and rigidly lock it in position. When it is required to uncouple wagons a release lever at the side of one wagon is pulled over, and this lever swings the pawl on its pivot to disengage its hooked end from the hook face. As this unlocking movement of the pawl is completed, a pad formed on its opposite end contacts the underside of the hook of the coupler on the other wagon, and pushes it up out of engagement with the complementary hook of the first wagon.

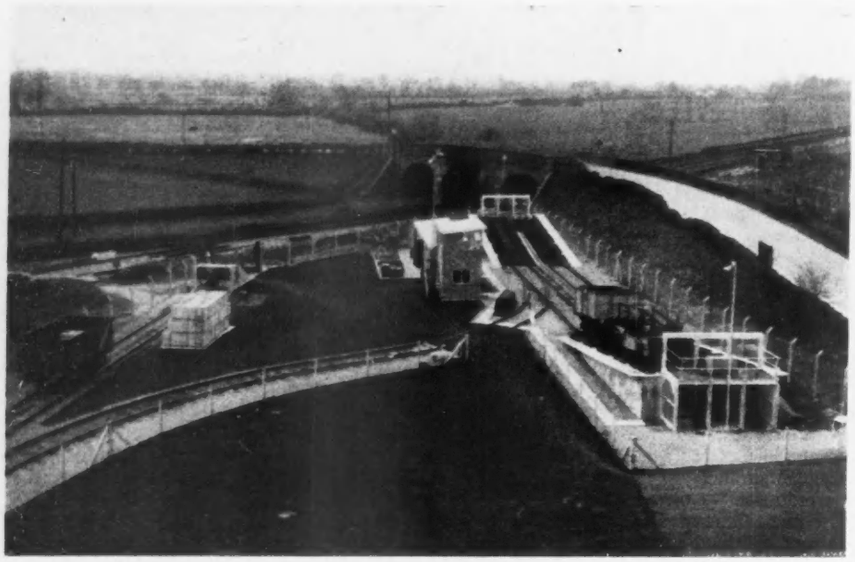
To enable wagons fitted with the automatic couplers to be used with standard drawgear, a standard form of chain coupling hook is incorporated on one side. This fitting enables a coupler to be swung at right angles and the standard drawhook presented. When wagons fitted with the automatic couplers have to be shunted without the couplers locking on each movement, the release levers are set in the unlocked position in a holding gate and, thereafter, as the wagons come together, the release pads on the locking pawls prevent the hooks moving into engagement.

The new rail test site shown in our illustration overleaf incorporates standard gauge track in straight runs and curves down to 1 chain radius. The ramp layout on the right of the site is used for impact testing purposes. One of the two tracks of this installation is used for standard wagon tests and the other for endurance and destruction testing purposes. On this second track, buffers and couplers are mounted on "dollies," to avoid unnecessary damage to complete wagons. The ramps at the two ends of these tracks are about 160ft apart and slope at angles of 15 deg. With this arrangement it is possible to attain impact speeds in excess of 25 m.p.h., or more than three times greater than the current average shunting speed. Adjustable scotches which are used to hold wagons on the ramps slide on a light-section rail between the rails and are positioned manually to determine impact speed. These scotches are pinned in position on to their rails and the pin-holes are spaced in such a way to make possible wagon impact speed adjustments in increments of 1 m.p.h. Winches which are used on each ramp for hauling up the wagons are driven by Dowty hydraulic motors. The hawsers of the winches are fitted with blocks





(Left) Wagon coupler which will engage and lock under a wide range of track curvature and gradient conditions, simultaneously connecting the vacuum brake pipe. (Right) Draught simulation rig for testing automatic rail wagon coupler



Part of the railway equipment test site, showing the gradients on the right for buffer impact tests and the buffer block on the left

which engage fixtures on the wagons and haul them over the scotches, where they are held by their axles. Each scotch has an over-centre toggle mechanism actuated by a hydraulic ram, and the wagons are released by withdrawing these scotch rams. Wagons with gross laden weights up to 40 tons can be used on the ramps.

All operations are controlled from a console on the upper floor of an observation room situated alongside a level section of track between the ramps.

Buffer testing covers the electronic recording of three basic essentials from which it is possible to compile a complete performance analysis. A strain gauge pressure pick-up is screwed into the end wall of the buffer pressure chamber to measure reaction variation on impact. The gauge is calibrated before the tests to determine the relationship between pressure and resistance. This strain gauge forms part of a Wheatstone bridge circuit, and voltage changes produced during an impact are fed into a d.c. amplifier and then into a driver amplifier of the first channel of a three-channel C.R.O. set. The beam movement caused by changes in pressure is calibrated by switching a fixed resistance into the bridge. The second channel of the C.R.O. set records wagon motion. A potentiometer, in which the sliding contact is fastened to a probe, is mounted so that the probe contacts the wagon 6in before the buffers meet. Just as the buffers touch, the sliding contact is arranged to coincide on the potentiometer winding with a fixed contact which changes the polarity of the voltage after the slider has moved past this point. The time scale of these two traces is obtained by feeding signals at one two-hundredth of a second intervals from a fork-controlled oscillator into the third C.R. channel and recording the pulses simultaneously with the signals from the other two channels. All three traces are recorded photographically. From this information, there can be calculated : wagon impact velocity ; deceleration of wagon ; force reaction at buffer on impact and during deceleration ; buffer shock absorption capacity ; energy destruction efficiency of buffer ; buffer stresses ; and the kinetic energy of wagon. By using additional strain gauges, stresses in various parts of the wagon frame and the effect of load movement during impact are also analysed.

Coupler testing on the ramps is carried out to prove the geometry of the design and the strength of the materials under accelerated endurance shunting conditions. At the same time instruments are used to record the efficiency of the automatic vacuum braking connection incorporated in the coupler. Gathering and uncoupling tests are undertaken on the separate special section of track, which has been laid down to reproduce simultaneously the most severe curvature conditions occurring in British Railways and a comprehensive range of vertical and horizontal misalignment.

The site has been equipped with a number of static rigs for the endurance and fatigue testing of buffers under specific conditions. These rigs are hydraulically operated using sequence control equipment of the firm's own manufacture. On one rig, buffers are subjected to a rapid cycling test to establish the rate of buffer head wear and also the efficiency of the vacuum sealing arrangement. This rig automatically cycles to give forty full closures per minute, and buffers undergo this test in batches of six, so that test figures can be compiled from a factual average. We are informed that so far it has been established that after 200,000 complete cycles about one pint of oil is lost and, in terms of railway usage, this means that a buffer will require oil replenishment just once in every five years.

We illustrate an interesting draught simulation rig for the automatic couplers, designed to vary the degree of misalignment rapidly whilst maintaining a heavy drawbar pull. This rig consists of a fixed head connected to a roller mounted sliding head, and the two ends of an automatic coupler are mounted by normal drawbars in the respective heads. Four hydraulic jacks are positioned, one at each corner, between the heads, and are used to subject the coupler assembly to a simulated drawbar pull of up to 50 tons, or up to 120 tons when carrying out tensile tests. At the fixed end of the rig the drawbar is fixed on a gimbal mounting coupled to vertical and horizontal hydraulic jacks. Through these jacks the gimbal is reciprocated up to 5in in both the horizontal and vertical planes at up to 120 cycles per minute, to simulate the relative movements a coupler set is subjected to when in wagon service. It is pointed out that the rig actually subjects a coupler to far worse conditions than would be encountered in service on an existing railway track. When required, an enclosure can be built round the rig to enable tests to be carried out under different conditions. Dust, sand and water can be injected into the enclosure in turn at varying intervals, and freezing conditions can also be created. During the tests instruments continuously indicate the degrees of misalignment, drawbar pull and vacuum connection efficiency.

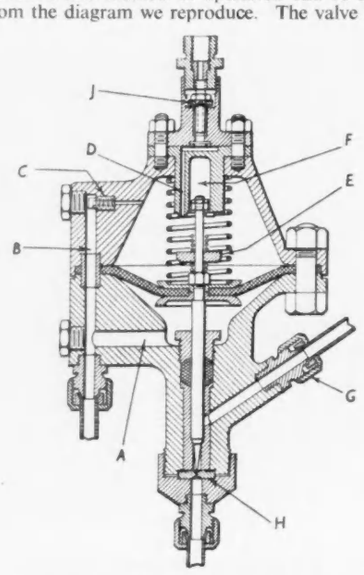
At the end of a straight test track is a 70-ton buffer block used, among other things, for the standard British Railway inspection test for buffer head strength. Buffers are mounted on the block at an angle of 30 deg. and are impacted by a buffer plate attached to a wagon. Impact speeds up to 17 m.p.h. are attainable.

In the course of a recent visit to the test site we saw a number of the standard tests which the firm uses for its couplers and buffers. In one of these tests two 16-ton mineral wagons, fitted with central couplers and 24½in hydraulic buffers, were coupled on a straight track at speeds of approximately 2 m.p.h. and 10 m.p.h., and then on a 6 chain curve. Wagons were then shunted around to show the ability of automatic coupled wagons to negotiate 1·1 chain curve and a 3 chain reverse curve.

In tests on the buffer block track a 13-ton wagon, with a load of 1½ tons of sand bags, was used. With hydraulic buffers fitted to both block and wagon, the wagon was shunted into the block at a speed of 16 m.p.h. without damage to either. Standard spring buffers were then fitted to the block and wagon and the wagon shunted into the block at a speed of 14 m.p.h. As a result of this impact, all four axleboxes on the wagon were broken, the horn frames distorted and the load displaced with such force that it broke the end planks of the wagon body.

Automatic Boiler Blow-Down Valve

AN automatic blow-down valve for boiler plants has been introduced, under the trade name "Carron-Smith," by the Carron Company, Carron, Falkirk. This valve, in addition to being automatic in operation, is self-clearing and effects the removal of boiler blow down in relation to the amount of feed water introduced. Its construction and method of operation can be seen from the diagram we reproduce. The valve has



Section through automatic blow-down valve

a phosphor-bronze body with internal working parts of Monel metal or stainless steel.

As can be seen, the main chamber in the body is divided into upper and lower compartments by a diaphragm of rubber, which is connected to a spindle, and a spring above the diaphragm loads it in the downwards direction. A line from the pressure side of the feed pump is connected through the bore *A* to the lower chamber in the body and a bleed from this bore is taken via the port *B* to the chamber above the diaphragm, an orifice plug *C* controlling the amount of bleed water.

When the diaphragm is forced up against the spring loading by the pressure of water in the lower chamber, a small quantity of the water in the upper chamber is forced out through the release port *D* and the discharge pipe above. The diaphragm moves up with the spindle until the pressure release valve *E* reaches its seating over the release port *D*. At this stage the diaphragm is in its uppermost position and the top of the valve spindle is in contact with the underside of the pressure release cylinder *F*. The line connected to the bottom of the unit is then cleared by the lower end of the spindle to give a clear passage to the blow-down connection *G*.

Pressure continues to build up in the top chamber through the orifice plug and keeps the release valve on its seat until the pressures in the top and bottom chambers begin to equalise. The spring load on the diaphragm then comes into effect to force the spindle down to close the blow-down opening. It will be appreciated that the frequency of this cycle is controlled by the size of the orifice in the plug *C*.

Before the bevelled seat at the lower end of the spindle seats, the needle end of the spindle penetrates the orifice in the blow-down disc *H*, and removes any obstruction which might be lodged there. Nuts at the top of the spindle and a small pressure release spring force the release valve *E* off its seating when the spindle has descended part of the way and a small quantity of water in the top chamber is allowed to escape through a stabiliser valve *J*. When the pressure in the top chamber is released in this way the operational cycle is completed. Blow-down orifice discs control the amount of water blown down and are normally available with $^{3}/_{64}$in, $^{1}/_{16}$in and $^{5}/_{64}$in orifices; they are selected in accordance with blow-down requirements governed by the steaming factors, such as hard water and percentage of condensate returned.

With this unit it is pointed out that the advantage of the operation is that its function is dependent upon the supply and pressure of feed water to the boiler. There is, therefore, a definite relationship between the amount of water blown down from the boiler and the amount of feed water being introduced to the boiler with its associated scale-forming or other salts.

Evaporatively Cooled Engine

THE principle of high temperature cooling in an evaporative cycle has been developed for application to diesel engines by Mirrlees Bickerton and Day, Ltd., of Stockport, and one of the company's engines, so equipped, has been installed in a factory in Belfast. This engine has operated successfully, and since its installation a considerable amount of research and experimental work on evaporative cooling has been carried out at the company's works. (See THE ENGINEER, page 70, January 10, 1958.) The data so obtained have played their part in helping the company to obtain the contract for two evaporative cooled diesel engines to be supplied to the United States Information Agency. These engines are mark KVS.12 turbo-charged industrial diesel engines, rated to develop 2724 b.h.p. at 450 r.p.m., and will be directly coupled to alternators manufactured by the Brush Electrical Engineering Company, Ltd., and will have an output, when on site, of 1750kW, 2187kVA at 0·8 power factor, 4160V, three phase 60 c/s. The engine, of Vee form, has twelve cylinders of 15in bore by 18in stroke, a compression ratio of 11·35 to 1 and a brake mean effective pressure of 126 lb per square inch. It is a totally enclosed four-stroke, solid injection, four valves per cylinder unit fitted with two Brush air-cooled turbo-chargers and able to maintain a two-hour overload rating of 110 per cent.

Contract requirements called for the engine to operate on a thermo-syphon jacket cooling water circuit and at a maximum water outlet temperature of 250 deg. Fah, corresponding to a steam pressure of 15 lb per square inch, instead of the normal closed circuit cooling system having a water temperature of 180 deg. Fah. at the engine jacket outlet and heat exchanger cooling. No circulating pumps were to be incorporated, so that circulation had to be natural.

Cooling is effected by removing the latent heat from the jacket circulating water in the form of steam and this high temperature cooling on an evaporative cycle means : that a constant circulating water temperature is maintained ; that exhaust gases do not fall below their dew point, so that cylinder wear is reduced ; and the steam available can be put to a number of uses. Where heavy fuel of 3500 seconds viscosity is employed the steam can be used for heating the fuel to bring it to the correct viscosity, or the steam can be employed for space heating, process work or distillation.

In the evaporative circuit heat is given up to the circulating water until it reaches a temperature governed by the steam pressure adopted, namely, 212 deg. Fah. at atmospheric pressures rising to 250 deg. Fah. at 15 lb per square inch. The closed system of circulation is linked with a steam separator where the circulating water, due to a drop in pressure, flashes off into steam thus removing excess B.Th.U. as latent heat. For this particular contract steam is arranged to pass out of the separator unit at 15 lb per square inch and is to be utilised to raise the temperature of heavy fuel and for sea water distillation. Approximately 0·6 lb to 0·7 lb of steam per horsepower is generated. Each bank of cylinders has its own separator and each operates independently, the water level being automatically controlled by Mowbray electric water level units each operating a ram pattern make-up feed pump.

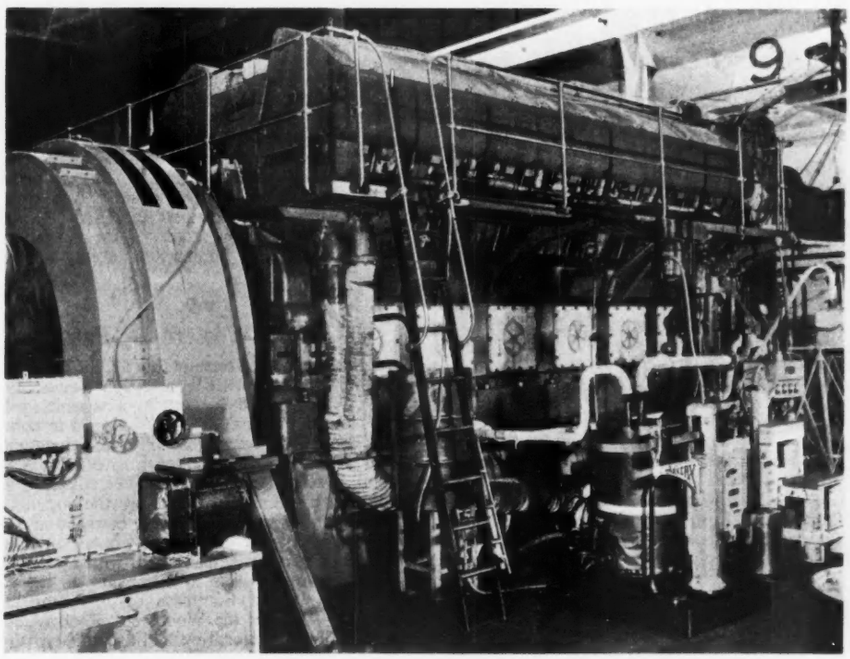
The test rig for one of the engines, which we saw recently undergoing trials and is illustrated herewith, included two separate steam condensers to condense the steam from the separators. This was led to a feed tank and pumped, by ram pattern pumps, back into the circulating water system. Control of engine speed is by a Westinghouse governor which is a combined electrical and mechanical unit, the mechanical section consisting of a combined actuator and hydraulic power pump mounted on the engine. Generator frequency, generator load and the fuel rack position is measured by an electric unit consisting of a frequency sensing, load sensing and fuel rack position sensing circuits. These circuits are fed into a magnetic amplifier totaliser which passes signals to the hydro mechanical actuator system for it to adjust the fuel supply according to demands. The governor performance has a steady constant speed run-up from no load to full load of $\pm 0{\cdot}3$ per cent and also ensures that any momentary speed change, when the load is suddenly changed from no load to full load and vice versa, will not exceed ± 3 per cent.

Should additional heat be required at site provision has been made for fitting an exhaust gas boiler to generate steam at 200 lb per square inch, any excess of steam at this pressure being fed through a reducing valve into the 15 lb per square inch system. With these arrangements for waste heat recovery an overall thermal efficiency of about 80 per cent is possible, while if heat is recovered from the lubricating oil the efficiency is raised to approximately 85 per cent.

The heavy fuel on which the engine will operate will be fed to the injection pumps at 40 lb per square inch, but should the pressure fall below 15 lb per square inch a gear driven pump will automatically deliver diesel oil at 15 lb per square inch to the fuel racks. On the test rig electric heaters were being used to raise the temperature of the fuel to the operating level of 230 deg. Fah. A sea water cooled heat exchanger will cool the lubricating oil, the maximum temperature of which is not to exceed 170 deg. Fah.

A nominal time for the circulating water to reach 212 deg. Fah. is about twenty minutes and it is understood that the temperature is constant over the load range of from 40 to 100 per cent. The water continues to circulate for approximately twenty-five minutes after shut down.

The engines at present building are stated to be the largest in which evaporative cooling has been employed, and the company believes that the system can be applied to a large range of engines, including marine units. It is understood that such engines are being used in coastal vessels in America.



"KVS. 12" Mirrlees engine fitted with high-temperature cooling on an evaporative cycle, undergoing shop tests

SHORTER REPORTS

Acoustic Waves in Structures

THE forty-fifth Thomas Hawksley Lecture entitled "The Transmission and Radiation of Acoustic Waves by Structures," was presented to the Institution of Mechanical Engineers last Friday by Leo L. Beranek of the Massachusetts Institute of Technology. Of major interest to architects, designers of vehicles, and acousticians is the control of structure-borne sound. Walls and panels are set into vibration by airborne waves or by vibrating mechanisms. The panel so excited will radiate sound and it may carry the vibrations to other panels or bodies. In the lecture, the author treated the problem of acoustic transmission through walls and panels in the audible frequency range. At low frequencies the panel vibrates as a plate or a stretched membrane. At higher frequencies the panel may behave as a quasi-infinite sheet. Above a particular "critical" frequency, the wavelength of the bending waves in the panel will be longer than the compressional waves in air at the same frequency. The two wavelengths may be brought into coincidence provided the airborne wave impinges on the panel at an angle θ determined by

$$\cos\theta = c_a/c_b$$

where c_a and c_b are the speeds of sound in the air and panel, respectively. At the coincidence angle, an airborne wave striking one side of a panel will set it into a level of vibration such that the magnitude of the airborne wave radiated from the other side may be only a few decibels below that of the incident wave. This effect was discussed both for airborne waves impinging at individual angles of incidence and for waves at many angles of incidence simultaneously. Measurements on plates, concrete sheets, and masonry walls were presented and analysed. Analysis of the different types of response to airborne wave excitation was made. Rules for the selection of simple and complex structures for buildings and vehicles were suggested.

Means for reducing the response of structures to airborne wave and mechanical excitation include the use of damping materials in or on the structure, the introduction of discontinuities and the use of sound-absorbing blankets in the structure. Recent data on damping materials and means for utilising them to produce maximum reduction of flexural waves were presented. It was shown that by proper utilisation of such materials a structure-borne wave may be attenuated in a given distance by a factor of 10 or more than when utilised in a conventional manner.

Latina Nuclear Power Station

THE foundation stone of Italy's first nuclear power station was laid at Latina, near Rome, on November 20. Amongst those present at the ceremony were Signor Giorgio Bo, Italian Minister for Industry; Lord Mills, the British Minister of power, and Sir Claude Gibb, chairman of the Nuclear Power Plant Company, Ltd. The Latina nuclear power station will be the first product of the collaboration between Ente Nazionale Idrocarburi (E.N.I.) of Rome, and The Nuclear Power Plant Company, Ltd. (N.P.P.C.), of Knutsford, who, in May, 1958, entered into an agreement for long-term co-operation in the design, construction and development of power reactors in Italy. The agreement also covered the exchange of information on the design, construction and operation of nuclear power stations, the training of technical staff and collaboration in research.

There are five main concerns in the framework of E.N.I. One of these, AGIP Nucleare of San Donato Milanese, near Milan, will undertake the civil engineering and building works at Latina, in close co-operation with the N.P.P.C., and will also be responsible for the correct manufacture and testing of all components to be made in Italy. The customer for the power station is the Societa Italiana Meridionale per l'Energia Atomica (S.I.M.E.A.), of Latina, an organisation owned jointly by AGIP Nucleare and the Istituto per la Ricostruzione Industriale (I.R.I.). The N.P.P.C. will be responsible for the overall design of the station and for its satisfactory commissioning; it will supply the major components, including the reactor itself, and the special boiler heat transfer elements. The contract for the 200MW station was signed in September last and is worth £20,000,000, equally shared between British and Italian industry. The technical particulars of the 200MW reactor are tabulated below. Work has already started and the station is expected to be completed in 1962.

Technical Data for 200MW Gas-Cooled Graphite-Moderated Reactor at Latina

Reactor core:	
Core diameter	14·5m
Core height	9·45m
Number of fuel channels	2980
Number of control rod channels	100
Channel diameter	105mm
Lattice pitch	203mm
Number of elements per channel	8
Total uranium in one charge	275 tonnes
Maximum average thermal flux in moderator	$2·3 \times 10^{13}$ n/cm²/sec
Mean uranium rating	2·5MW/tonne
Reactor heat output	705MW
Initial conversion factor	0·83
Reactor vessel:	
Mean diameter	20·35m
Thickness	90mm
Number of openings	230
Maximum working pressure	13·4 atm. abs.
Total estimated weight	1636 tonnes
Coolant system:	
Number of circuits	6
Diameter of ducts	1680mm
Reactor gas inlet temperature	180 deg. Cent.
Reactor gas outlet temperature	390 deg. Cent.
Blower power (total)	19MW
Boilers:	
Number of units	6
External dimensions	5·698m dia. × 24·09m high
H.P. steam conditions	52·4 atm. abs. × 373 deg. Cent.
L.P. steam conditions	14·3 atm. abs. × 373 deg. Cent.
Main turbo-alternators:	
Number and output	3 × 70MW
Speed	3000 r.p.m.
Feed water temperature	88 deg. Cent.
Net station electrical output	200MW

District Line Modernisation

THE first major stage in the scheme to modernise the eastern section of the London Transport District Line will be completed on Monday, December 1, when part of the new depot at Upminster is brought into use. These works on the District Line, costing some £2,500,000, constitute the most important Underground project since the post-war extensions of the Central Line. The Upminster depot, on which £1,000,000 has been spent, has some 4 miles of track and will accommodate thirty-four eight-car trains; it has a main car shed 450ft long, with nine inspection roads and a 215ft long lifting shop. The new depot is now being used for operating purposes and train examination work, but heavy maintenance will not be undertaken until next May, when the depot is fully equipped.

Train movements into and out of the depot, which is at the eastern end of Upminster Station, will be directed from a 40ft high control tower equipped with radio "talk-back" apparatus. Instructions from the tower will be heard only by the train driver concerned through a trackside loudspeaker, and the driver's acknowledgment, given at ordinary speech level, will be picked up by a trackside microphone and relayed back to the control tower.

In addition to the new depot, the 12½ miles of the District Line from Bow Road to Upminster are now being completely re-equipped with London Transport's standard signalling, and trains will be controlled from two push-button signal cabins at Barking and Upminster. Nine other unmanned signal cabins will be remotely controlled by one or other of the master cabins through interlocking machines.

The new depot replaces the present one between East Ham and Barking, the site of which is required by the Eastern Region of British Railways in connection with the electrification of the Fenchurch Street-Southend Line. These improvements on the Upminster Line are linked with the track rearrangements at Barking now being carried out by British Railways (Eastern Region). When these works are completed in 1960, the flat junctions will be eliminated and both the District Line and main line services will have independent tracks. The junctions at Barking, which are used daily by 700 Underground and main line trains, have been a frequent cause of delays in the past, and the modernisation of the District Line will result in improved running throughout the line in both east and west London.

Scientific Work at Halley Bay

THE third party of scientists and technicians of the Falkland Islands Dependencies Survey to sail for the Antarctic this year left Southampton last week-end aboard the M.V. "Tottan." They will be taking over the Royal Society base at Halley Bay (Coats Land) at the end of December. It will be recalled that Halley Bay base was established by the Royal Society expedition in January, 1956, as part of Britain's contribution to the International Geophysical Year. It would normally have closed down at the end of this year when the field work of the International Geophysical Year is completed. Acting on the recommendations of British scientists, however, the Government has decided that scientific work at Halley Bay should be continued. This decision was announced by the United Kingdom delegate to the special committee on Antarctic research at its Moscow meeting in August.

During 1959 the Falkland Islands Dependencies Survey party at Halley Bay will carry out an intensive programme of meteorological and other research work, including radio-sonde observation of the upper atmosphere. Meteorological information will be broadcast from the base and the results of research carried out there will be published by the Falkland Islands Scientific Bureau. In addition to Halley Bay base, the Falkland Islands Dependencies Survey, which is under the direct administrative control of the Governor of the Falkland Islands, maintains permanent bases on the mainland and surrounding islands of Graham Land. At these bases between eighty and ninety scientists and technicians carry on systematic research into all aspects of the British sector of the Antarctic, including studies of human adaptability to low temperatures.

Oxford Western By-Pass

WORK is expected to start shortly, the Ministry of Transport and Civil Aviation states, on building the Oxford Western by-pass which will cost more than £1,500,000. It is hoped to complete the scheme by March, 1961, and there will then be an almost complete ring of by-passes round Oxford, including the Northern and Southern by-pass, finished before the war, and the Eastern by-pass now nearing completion.

The Western by-pass will be 3½ miles long and will run largely on embankment with a number of bridges and a large fly-over. It will extend from the Oxford Southern by-pass road at Botley (A.4141) to the Woodstock Road (A.34) about half-a-mile north-west of its junction with the Oxford Northern by-pass (A.40). There will be two 24ft carriageways throughout its length, separated by a 10ft reservation.

Interesting engineering features include a

viaduct about 250ft long at Wolvercote, where the by-pass crosses the Northern by-pass, a canal and a railway. The bridge over the Thames will have a span of about 140ft and will be 75ft wide between parapets. Over the Mill Stream there will be a bridge with a 66ft span. Very heavy earthworks are involved to form the embankment, and about 600,000 cubic yards of fill will have to be brought on to the site. At Botley the road will cross the Faringdon Road A.420 on a fly-over 110ft long and 65ft wide, leading to a roundabout with a link road connection to A.420. The scheme has been prepared for the Minister of Transport and Civil Aviation by the Berkshire County Council, County Surveyor, Mr. K. B. Brow, M.I.C.E., M.I.Mun.E. The consulting engineers for the Wolvercote Viaduct, River Thames bridge, and Mill Stream bridge are Messrs. R. Travers Morgan and Partners. The Minister has approved the letting of the contract to Higgs and Hill, Ltd.

Ball Bearing Slewing Rings

We illustrate one form of a ball bearing slewing ring for machines such as cranes and excavators, made at Crown Works, Sunderland, and marketed by the Roballo Engineering Company, Ltd., 43, Dover Street, London, W.1. These rings are made in two ways—one with a single row of balls and two ring components ; the other with a double row of balls and three ring components as shown in the illustration. The

Typical three-part ball bearing slewing ring with internal spur gear

single row design is mainly intended for taking up radial loads and axial loads up to about 10 tons combined with small tilting moments. The double row designs incorporate a " collar " ring between the rows of balls and this ring arrangement absorbs high axial and radial loads and large moments. The ring components, of forged steel, have surface-hardened ball-races ; the loads are carried by precision steel balls separated either by intermediate balls, spacers, or by a cage. A toothed rim machined into one of the rings to take the drive for rotating motion may be designed as a spur gear, with internal or external teeth, or as worm or bevel gear. The inner and outer rings are easily fixed on the adjacent frameworks of a base and a rotating structure, by a number of bolts spaced at uniform intervals about the periphery. The accurate centring of inner and outer rings ensures precise operation and close mesh of the gear drive. Seals are not normally necessary, but may be fitted to prevent the possible ingress of dust or other foreign matter. Lubrication is effected through pressure grease fittings by grease gun or from a centralised lubricating system.

Ball bearing slewing rings of this design can be manufactured economically in diameters up to 13ft, and rings capable of absorbing axial or thrust loads up to 500 tons and tilting moments up to 2500ft-tons have been successfully manufactured. Larger loads can be carried on segmented slewing rings, which can be made up to 45ft in diameter.

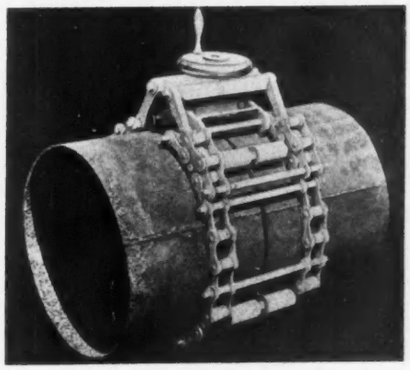
Slagging Pressure Gasifier

In our notes on the new Midlands Research Station of the Gas Council at Solihull in the issue of April 18 last, brief mention was made of the pilot slagging gasifier which had been installed. An interesting paper describing this plant and the experiments being carried out on it was presented at the recent autumn meeting of the Institution of Gas Engineers by Dr. D. Hebden and Mr. R. F. Edge. This paper describes experiments with the gasifier operating on steam and oxygen at a pressure of 75 lb per square inch and using oven coke as fuel. They were mainly concerned with the examination of various methods for removing the liquid slag from the gasifier. The most satisfactory operation was obtained by using hot gases to hold the slag back in the hearth, tapping periodically, and quenching the slag in water. With this procedure, the slag was discharged at a high rate which minimised the effect of heat loss, supervision was only required during the tapping operation, and the slag outlet could be used as an auxiliary tuyère to control the temperature of the slag independently.

Results show the influence of varying the relative amount of steam from 8 to 1 v/v of oxygen, i.e. from conditions required for dry ash removal to those for slagging. They are used to estimate the performance to be expected when operating a slagging gasifier on coal at 300 lb per square inch. It appears that, in comparison with dry ash removal, a slagging gasifier will have a 12 to 15 per cent higher thermal efficiency, will use only one-fifth the amount of process steam, and will produce only one-sixth the volume of liquor. By-product recovery will be simplified in consequence. The output will be increased, probably three to four times, to make units of 30,000,000 cubic feet per day capacity possible. Depending on the ash content the oxygen consumption per therm of gas will be 15 to 25 per cent higher and, with bituminous coal, the calorific value of the gas might be 360 to 375 B.Th.U. per cubic foot instead of 400 B.Th.U. per cubic foot.

Pipe Support Clamp for Welding

An adjustable pipe clamp for aligning and holding pipe ends together for tack welding purposes is made in three sizes by Coltburn Positioners, Ltd., Goldington Bury, Bedford, for pipes from 6in to 12in, 12in to 18in and 18in to 24in outside diameter. These clamps, one of which is illustrated, consist of two sets of roller chains connected by spacer bars and linked at their ends by claws which engage over the



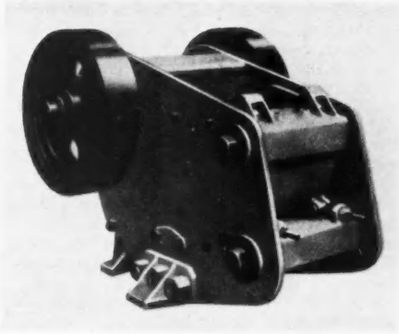
Clamp holding pipe ends in alignment for tack welding

appropriate spacer bars. The claws are pivoted at their centres in a clamping block and the assembly is tightened on the pipe ends by drawing the claws together by turning a hand-wheel at the top of the block.

Large rollers are set between the chains and adjacent to the spacer bars located on the pipe surfaces, and through these rollers the actual clamping pressure is applied to the pipes. A sufficient distance is left between the support rollers for adequate tacking of the pipes ready for final welding when the clamp is removed.

Stone Granulator

A stone granulator known as the " Phoenix," now made by Robert Broadbent and Son, Ltd., Stalybridge, Cheshire, is designed to produce a uniform aggregate of uniform size at high output rates. This machine, although relatively small, as can be seen from the accompanying illustration, is designed to reduce 4½in to 5½in granite to



Stone granulator in which the moving jaw oscillates about a horizontal axis

¼in at a rate of 3½ to 4½ tons per hour and down to 1in at a rate of 11 to 12 tons per hour.

The moving jaw of the machine is driven by a roller bearing eccentric shaft, and is so arranged that during crushing the jaw oscillates about a horizontal axis. This method of jaw oscillation is stated to ensure the production of a cubical aggregate with the minimum amount of dust and scale, whilst abrasive wear on the jaw plates is reduced.

Protective Coating

To provide protection from corrosive attack from atmospheres impregnated with fumes and gases of alkali or acid character E. S. Hughes and Co., 2, Everton Terrace, Liverpool, 5, has developed a formula for a coating which is to be marketed under the name of " Styrene." This is a new water-suspended plastic which is non-toxic and odourless and can be applied as ordinary paint to surfaces which must be stripped of previous coatings and free from dust, oil, and grease. Cold water is used for thinning and the paint does not require an undercoat, except for steel. However, two coats are normally required and, when dry, after about two hours, create a tough, non-brittle, semi-gloss finish. Many advantages are claimed for the new formula and these include :—ability to withstand scrubbing, boiling water and low and high temperatures ; impervious to moisture ; will not powder, swell or soften, and does not absorb oil or grease. The paint is manufactured in a number of shades and 1 gallon gives a coverage of 80 square yards, depending upon the porosity of the surface. A number of tests have been carried out, one of which consisted of coating a section of a concrete runway and observing that no deterioration occurred despite the impact of exhaust gases from turbo-jet engines. In another test a section of coated plywood was submerged in sea-water for six months and emerged unaffected. Tests have been completed more recently at Liverpool to demonstrate that the coating is unaffected by soaking in many acids, including sulphuric and nitric up to 20 per cent, and is non-inflammable and abrasion resistant. Samples of concrete, common brick, asbestos, timber, plywood, hardboard, were coated and subjected to rubbing by sandpaper, and both sulphuric and nitric acid were applied to a number of coated surfaces. In another demonstration fine tissue paper was coated on one side and the paper removed by the application of sulphuric acid to leave a sheet of paint. This did not burn when a flame was applied to it, and it was later soaked in nitric acid without showing any ill-effects. In the heat test mild steel sections were coated on one side and heat applied without affecting the paint.

Automatic Cut-Off Machine

AN automatic machine for cutting off non-ferrous materials and plastics from bars 2in diameter or equivalent section has been developed by S. Russell and Sons, Ltd., Bath Lane, Leicester. This machine, as can be seen in the illustration below, has a saw head mounted on a cabinet base, at the side of which there is a rack storage unit with a bar feed mechanism.

The saw spindle together with its 5 h.p. motor and belt drive are pivotally mounted on a rocking head on the base, and in the cutting off operation an air cylinder at the rear feeds the saw into the work by pushing the rear of the rocker mounting upwards. The spindle runs at 1800 r.p.m. and is designed to take up to 9in diameter saws $^{1}/_{16}$in or $^{3}/_{64}$in thick. A hydraulic dashpot regulated from the front of the machine controls the speed at which the saw is fed into the work, and gives a steplessly variable feed speed with a quick return stroke. The length of the cutting stroke is adjustable so that the machine can be set for a minimum lost motion when cutting different sizes of bars and to compensate for different diameter saws.

A micrometer length stop is mounted on a bar at the point of the head and is adjustable along the bar in increments of 1in by means of a locating pin. Using the increment setting in conjunction with the micrometer, lengths of material can be cut consistently to precision limits without using any other form of measurement. A hardened steel pin is carried in a bore in the centre of the stop and this pin operates a micro-switch when the work contacts the stop in the bar feed movement. This micro-switch closes the work gripping vice and starts the saw on the cutting stroke when it is contacted. At the end of the cutting stroke another micro-switch is operated to institute the fast return of the head. When the return movement is completed a switch is contacted and opens the vice jaws ready for the next bar feed stroke.

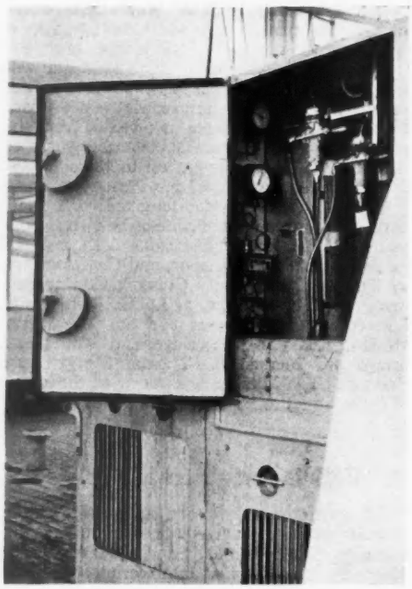
In the bar feed unit, which has a standard maximum stroke of 12in, the bar on the conveyor at the foot of the rack is fed forward constantly towards the cutting position by a trolley driven by an air motor. When a bar is finished the trolley is returned by operation of a lever to the far end of the track where it contacts an air valve controlling a series of cams which lift the next bar from the sloping storage rack and place it on the conveyor. Pressure on the feed bar can be adjusted to suit the class and size of material being handled. In order to ensure that a square cut is made across the material the micro-switch in the feed stop makes contact only when within 0·002in of being flush with the face of the stop—thus if a bar end is not square it will not push the pin home and the machine will stop.

Air Conditioning Conversion Units

TO-DAY on board ship there is an increasing demand for air conditioned ventilation which has involved the problem of modernising, in this respect, existing mechanical ventilation systems. This problem has been occupying the attention of Thermotank, Ltd., Helen Street, Glasgow, and towards its solution the company has developed a new air conditioning unit which is known as Type "C." This unit has been specifically designed to convert, inexpensively, existing heating and ventilation systems to full air conditioning with the minimum of structural alterations. It is intended to be mounted on an open weather deck but can be fitted elsewhere in the ship, always provided that a clear headroom of 7ft 6in is available (for the largest unit) and a deck space of not less than 5ft 6in square. Unit sizes range from 4 tons to 20 tons refrigeration with a nominal air circulation of from 1500 to 5500 cubic feet per minute. To facilitate handling and to surmount installation difficulties, especially in restricted spaces, the equipment is manufactured in two parts which can easily be bolted together. In the upper part are housed the cooling coil, filters, air dampers, &c., while the lower section contains the Freon compressor, motor, condenser, &c. Connections require to be made to the existing fan system and provision made for condenser water inlet and outlet, condensate drain piping, and electric wiring from a remote starter to the terminal box. In addition it may be necessary to increase the insulation of certain ducting and make provision for avoiding condensation, especially in those ducts which are behind panelling, and even incorporate re-circulation ducts.

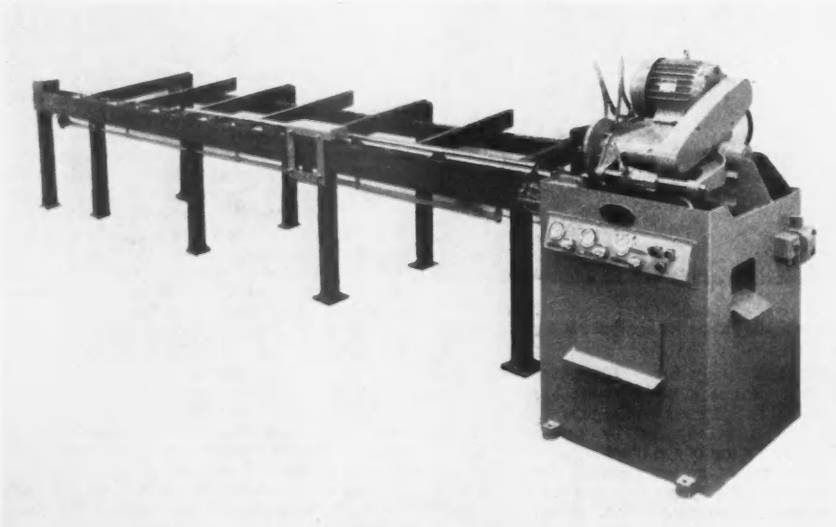
The heavy galvanised steel casing, forming the upper section of the unit, is insulated internally; it has openings cut to take air trunks and a hinged door to give access to the equipment. This includes an air cooling coil which is of extended surface pattern and is designed to operate vertically in separate sections as variations of duty require. The whole is housed in a rust-proof frame, and beneath is a condensate collecting tray with drains to outlet connections on both sides. There are two expansion valves which are thermostatically controlled by the temperature of the return gas from the air cooling coil and control the supply of Freon refrigerant. Also in the upper section is the control panel, viscous pattern air filters and the fresh air and recirculated air damper.

The lower section is constructed of heavy galvanised steel angles and channels with removable vented spray-eliminating steel side panels. In this section are mounted a multi-cylinder, vertical, single-acting refrigerating compressor belt driven by a two-speed electric motor, and a shell and tube condenser having mild steel end plates clad with stainless steel on the water side. There is a Freon strainer, which can be cleaned without disturbing the pipework, and two automatic Freon valves placed in the liquid line between the strainer and the two expansion valves in the upper section. Each valve supplies one expansion valve and is controlled by the unloading thermostat when capacity reduction is required, or by the second stage thermostat when no cooling is required. When the thermostats operate the magnetic valves, the motor starter automatically selects the correct speed for the compressor motor.



One of the three 20-ton capacity refrigerating units mounted in "Esso Canterbury"

Six Esso tankers are among the ships being converted, and three 20-ton units, one of which can be seen with the access door open in our illustration, have been installed recently on the "Esso Canterbury" and are capable of maintaining interior conditions of 85 deg. Fah. dry bulb and 70 deg. Fah. wet bulb when the outside atmospheric conditions are 90 deg. Fah. dry bulb and 85½ deg. Fah. wet bulb. A recirculation duct has been fitted and, to avoid loss of conditioned air, natural exhaust vents have been blanked off and self-closing fittings mounted on all doors giving access to the outside atmosphere. The units are being marketed on a world-wide basis so that ships can be converted at most ports.



Machine for cutting bar material to length. Non-ferrous or plastics materials up to 2in diameter or equivalent section can be cut to standard lengths of up to 12in on an automatic cycle on this machine

Tractor Lubrication in Tropical Areas

A PAPER dealing with some modern aspects of agricultural tractor lubrication was presented to the Western Centre of the Institution of British Agricultural Engineers, on November 17, by Mr. W. J. Nolan, vice-president. One section of the paper dealt with tractor operation in tropical or semi-tropical areas. In such areas, it was pointed out, tractors might be required to work in a dusty atmosphere at temperatures ranging between 90 deg. and 130 deg. Fah. Under those conditions, it could be envisaged that lubrication of tractor engines was not an easy problem, since, apart from the effects of high ambient temperatures, the ingress of dust, in minute particles, would quickly contaminate oil and cause excessive wear. Furthermore, the cooling of an engine might not be sufficient to prevent the temperature of the crankcase oil from reaching a point where excessive thinning out took place and, where the viscosity of an oil was too low, reduced ability to form an oil film might cause bearing failures.

In the past, Mr. Nolan said, extreme high-temperature conditions had been met by operators using an oil of higher S.A.E. classification, e.g. S.A.E. 40, replacing S.A.E. 30. To-day, the latest developments had made it possible for such areas to operate tractors on a multi-grade crankcase oil, classified as S.A.E. 20W/40.

Industrial and Labour Notes

Mine Accidents

The report of the Chief Inspector of Mines and Quarries, for the year 1957, has been published this week. It is the first report under the Mines and Quarries Act, 1954, which came into operation in January, 1957. Consequently, it deals with quarries and "miscellaneous mines" in addition to coal mines.

The report records that, at the end of last year, 1435 coal mines were being worked in Great Britain. Of the total, 905 were operated by the National Coal Board and 530 were being worked under licence from the Board. During the year, the mine inspectors (excluding inspectors of horses) made 24,444 inspections, of which 15,729 were underground and 8715 were on the surface. There were 609 coal mines inspected throughout and in many mines individual working districts were visited by the inspectors several times.

As to accidents in coal mines, it is recorded that 395 men were killed and 1918 reportably injured during 1957, compared with 328 and 1748 respectively in 1956 (the lowest figures ever reported). The chief inspector says that last year's increase is regrettable, but is "not necessarily significant as an indication that the downward trend in accidents has halted." Nevertheless, he adds, there have been increases in the categories of falls at the working face and from explosions of firedamp that have caused concern. The chief inspector goes on to the comment that a disturbing general feature during 1957 was a failure to meet adverse conditions by means which are recognised as normal good practice. Safety research, it is emphasised, has conferred many advantages on mining men in recent years and better materials and appliances have become available. It is sad, the inspector remarks, that "in many individual cases the personal element should break down and that all this effort should fail to improve the standard of safety." The inspector hastens to add that he does not refer specifically to "carelessness or recklessness, significant though they often are." He means rather the remarkable frequency with which men and officials alike show an apparent blindness to approaching difficulties and fail to take precautions in time. The Coal Industry National Consultative Council has appointed a sub-committee, on which the chief inspector serves as an assessor, to consider recent explosions, to recommend preventive measures and to suggest ways of bringing those measures to the attention of management, under-officials and workmen.

Overseas Trade

The Board of Trade says that there was a "rather more buoyant trend" in overseas trade during October. The final figures for exports and imports show a fairly sharp rise over those for the preceding month. Exports of United Kingdom goods and manufactures in October were valued at £266,800,000 and imports at £328 million. Re-exports were valued at £12,200,000. The visible trade deficit was thus £49,000,000, which was £11,000,000 less than in September, but was well above the average level earlier in the year. Over the first ten months of this year, the Board of Trade adds, exports were 3½ per cent lower in value than in the comparable period of 1957.

The slightly higher overall level of exports in October, compared with the monthly average from January to September, came from increases in exports of foodstuffs and "other manufactures," which were partly offset by reductions in textiles and fuels. Engineering exports, the Board reports, were marginally lower and exports of metals were unchanged. The Board goes on to say that in the engineering divisions there were marked falls in exports of "machinery other than electric," and in road vehicles and aircraft, though these were offset by big increases in the exports of ships and boats and smaller rises in exports of electric machinery and railway vehicles. The decline in exports of "machinery other than electric," assessed at 6½ per cent, was fairly general, but, compared with recent months, was particularly marked in boiler-house plant, agricultural machinery and tractors, industrial trucks and mechanical handling equipment and machine tools. Exports of cars were only marginally below the very high January–September rate and included increases to the U.S.A. and Canada, though there were reductions to Australia and Western Europe. Exports of commercial vehicles and chassis were down by 16 per cent, however, and aircraft exports were 25 per cent lower. On the other hand, exports of ships and boats, which this year have been lower than in the past two years, more than doubled in October compared with the monthly rate from January to September; the October figure included delivery to India of vessels valued at nearly £5,000,000. In the metals group, iron and steel exports continued to decline in October and were 10 per cent below the January–September level, but this fall was balanced by a rise of 19 per cent in the exports of non-ferrous metals.

Census of Production Results

The first results of the census of production for 1957 have recently been published by the Board of Trade. The results for 1957, like those for the two preceding years, are based on a sample inquiry and cannot, therefore, be absolutely precise. For 1957, returns were obtained from about one in nine of the industrial establishments in Great Britain, including all the largest establishments. The sample accounted for about 70 per cent of the total output.

The value of the output of manufacturing industry was nearly 5 per cent higher in 1957 than in 1956. This, the Board of Trade points out, is equivalent to an increase of between 1 and 2 per cent in the volume of output. Increases in the value of output came mainly from the engineering, shipbuilding and electrical goods industries. Substantial increases were also reported in the chemicals, paper and printing, coal mining and electricity supply industries. A decrease in the net output in mineral oil refining was accompanied by increased sales; the lower net output in this industry is attributed to the disruption of oil supplies during the Suez emergency and the resultant higher prices of crude oil. The average number of people employed in manufacturing industry in 1957 was slightly higher than in 1956. The engineering group showed the largest expansion, though one of its constituents, namely, textile machinery and accessories, employed fewer people last year. There were reductions also in vehicles, including aircraft manufacture and repair. Outside manufacturing industry, there was a considerable increase last year in the number of people employed in coal mining. The Board of Trade says that the higher level of total employment in manufacturing industry was due entirely to an increase in the number of administrative, technical and clerical workers. As in earlier years, this category of workers continued to account for an increasing proportion of the total number engaged in industry. The average earnings of administrative, technical and clerical employees increased by just over 5 per cent between 1956 and 1957. It was the first time for some years that the increase in average salaries in manufacturing industry was as great as that in average wages.

Industry's total capital expenditure increased again in 1957, but the rate of expansion slackened; the increase for manufacturing industry last year was £82,000,000 compared with £139 million n 1956. There was a marked difference last year between new building work (on which the amount of money spent by manufacturing industry was about the same as in 1956), and expenditure on plant, machinery and vehicles, which increased by nearly £80,000,000. Much of this increase was concentrated in metal manufacture and in the chemical group of industries where capital expenditure in the oil refining industry reached a new peak and was almost double that of the preceding year. Although capital expenditure in the public utilities did not increase significantly in 1957, it continued at the very high levels previously reached and, together with capital expenditure in coal mining, accounted for nearly one-third of the total for all the industries included in the census.

Technical Salesmen

The Department of Industrial Administration of the Birmingham College of Technology is starting, in the new year, a series of short full-time courses for technical salesmen. This venture, it is believed, will help to solve a problem which faces many industrial concerns to-day, namely, how to be effective in selling products which "incorporate an increasing amount of technical know-how." Some of these sales problems can be met by backing up the professional salesman with technical advisory services. Nevertheless, there appear to be many situations in which it would be more economical and effective if the man directly concerned with the customer is himself a technologist. In any case, the Birmingham College of Technology points out, smaller firms cannot afford the expense of two men to deal with each selling problem. The difficulty, it is suggested, is that many technologists are not naturally good at "customer relations." The forthcoming courses have been designed to deal with matters such as this. A panel of senior marketing and purchasing executives in the Midlands has assisted in the preparation of the syllabus and more than half of each course will be devoted to case study and project work and interrogation meetings with people having a varied experience in customer relations.

The first of these courses will begin on February 16, 1959; all the places available for it have been taken up by companies which have participated in the preliminary discussions. Full details about subsequent courses can be obtained from the Department of Industrial Administration, College of Technology, Gosta Green, Birmingham, 4.

Centre National des Industries et des Techniques

No II—(*Concluded from page 824, November 21*)

Inaugurated by the holding of the "Mécanélec 58" Exhibition recently, the Palais des Expositions du Centre National des Industries et des Techniques (C.N.I.T.) is scheduled for substantial completion next year. The groined vault roof of the hall, seen in the aerial view (page 821), is inscribed in an equilateral triangle with sides measuring 218m, and supported at only three points. This structure, unusual in form and in design, constructed in very short time, holds two world records: the longest known span for a shell structure, 206m at each façade and 238m at the groins—the largest surface supported at a single point, 7000 square metres. The floor area totals nearly 100,000 square metres. Situated at the Place de la Défense, Puteaux, the projected Concorde-Etoile axis the C.N.I.T. forms the first building of an important development scheme.

The Roof

SEVERAL design proposals were submitted for the roof; some in concrete, some in steel, and others of a mixed nature. Professor Nervi's design envisaged three ridge beams rising from the corners and meeting at the centre of the roof. From there, a rhomboidal lattice work of reinforced concrete beams, 1·2m deep, and having a module of 3·5m, was to extend outwards, forming three cylindrical naves each at right angles to the corresponding façade. Each lattice section was to be covered by a convex sheet metal roof with metal tie members underneath.

M. Freyssinet proposed a spherical concrete shell roof with three straight vertical façades intersecting the roof. Inside was to be a monolithic, prestressed concrete floor, along the edges of which were to be placed ties to prevent the spread of the dome at the corners. The edges of the vault at the façades were to be supported by vertical cables spaced every metre and prestressed to 9 tonnes. These would also have served as supports for the glazing. The whole was to rest on columns, which in turn were to be seated on pads of synthetic rubber, thereby making possible free lateral expansion and contraction.

Projects envisaging a metal structure also based themselves on the idea of three intersecting cylinders supported between a central spider and a main girder at each façade, or as in Nervi's design, forming a lattice work of beams supported only by the central ridge beams, with a metallic roof.

A mixed steel-and-concrete design deserves to be mentioned. Like the other schemes described, this one also employed a central spider to support three cylindrical naves, which, however, this time were to be in the shape of a double shell of prefabricated triangular concrete elements connected by a lattice of steel tubes.

The project finally adopted was that of Monsieur N. Esquillan, who proposed a double shell roof, also, like some of the other designs, in the shape of three intersecting cylindrical portions, but transmitting its load directly to the three supports at the corners (Fig. 7). From these corners, the elements of the box structure, convex on top and concave underneath, radiate in the manner of a fan, towards horizontal transverse beams at the crown which form a three-armed spider, extending from a common centre in the middle of the roof at right angles to the façades. The box structure is completed by internal webs running out radially from the supports between the corrugations, and spandrels perpendicular to the façades. In front elevation the curve of each cylindrical nave is that of a catenary, so that the forces at each point in the concrete are entirely compressive.

As the sectional view in Fig. 7 shows, each nave of the roof comprises nine equal corrugations arranged in three groups, each of which is 20·82m wide at the crown. The distance between the top and bottom concrete surfaces is 1·8m, and the distance taken over the corrugations amounts to 2·8m. The angular spacing of the webs and corrugations is 3 deg. 20 minutes (one-eighteenth of 60 deg.), and the pitch of the spandrel walls is 9m. This cell structure is of such strength that the thickness of the material can be reduced to a minimum. At the crown the shells are only 6cm thick, and the internal walls are of this thickness throughout. Nearer the corners, the shell thickness had to be increased to about 15cm. For more than 85 per cent of the roof surface the thickness of the shells is equal to, or less than, 6·5cm. It has thus been proved possible to keep the deadweight to the very low figure of 14,200 tonnes without sacrificing rigidity.

For a construction where speed and economy were of such importance, the design proved to be of the greatest advantage. The shells had to be cast *in situ* and the very large amount of tubular scaffolding required to support the shuttering represented a serious problem. If the whole roof had been cast at the same time, some 400km of steel tubing would have been required. As the collection of such a quantity would have been wellnigh impossible, it became necessary to carry out the work in stages, so that the same scaffolding might be used more than once. Another important consideration was the time required to assemble the scaffolding. The mode of construction finally adopted met these points in an extremely neat and efficient manner.

All the three portions into which each nave is divided, as our title illustration (*ante*) or Fig. 8 show, are equal in area and, moreover, are identical in section at each level, and also in plan except for a horizontal lateral "shearing movement," as it were, of the generating section. It was thus possible to use the same scaffolding as well as the same shuttering, for each of the three sections, and to cast the roof in four stages: first, the corners adjoining the previously completed foundation blocks; secondly, the three central sections which were cast in one piece; then, separately, the middle, and finally, the outer sections. The sections, cast at four months' intervals, were kept entirely separate along the whole of their length in order to avoid stresses due to differences in shrinkage and creep.

The mix used contained 350 kg of standard Portland cement per cubic metre of concrete, and design stresses were kept within 100 kg to 130 kg per square centimetre. These stresses, according to the French regulations, require a concrete with a crushing resistance of 130/0·28 =465 kg per square centimetre after ninety days, as measured on test cubes of 20cm side. Although the stresses induced by the dead load alone do not exceed 80 kg per square centimetre, and although the strength of test cubes was already adequate after fifteen days, the shuttering was left in place for twenty-one days before being struck. Studies of creep had shown that deformations are considerably increased if high stresses are imposed on a concrete which is insufficiently aged.

By preassembling large sections on the ground and hoisting them into place by crane, the whole of the roof scaffolding was assembled in two months. The magnitude of this part of the work will be appreciated when it is realised that the centre scaffold portions, which extended from ground level to the underside of the middle of the roof, were about 50m high, while the adjoining sections, which stood on the central triangular floor, were up to 37m high, and the total of steel tubing amounted to 280km. The scaffolding for each nave consisted of five sections on either side of the central vertical plane. A special procedure was adopted to keep the scaffolding intact after each stage and move it laterally into position ready for the next stage. The shuttering was struck by forcing each completed roof section upward by means of hydraulic jacks. These jacks—which were fitted with screwed take-up collars as a safeguard against hydraulic failure—were placed in gaps left between the initially completed common roof section adjoining the foundation blocks, and the individual vault sections. Their line of action was along the

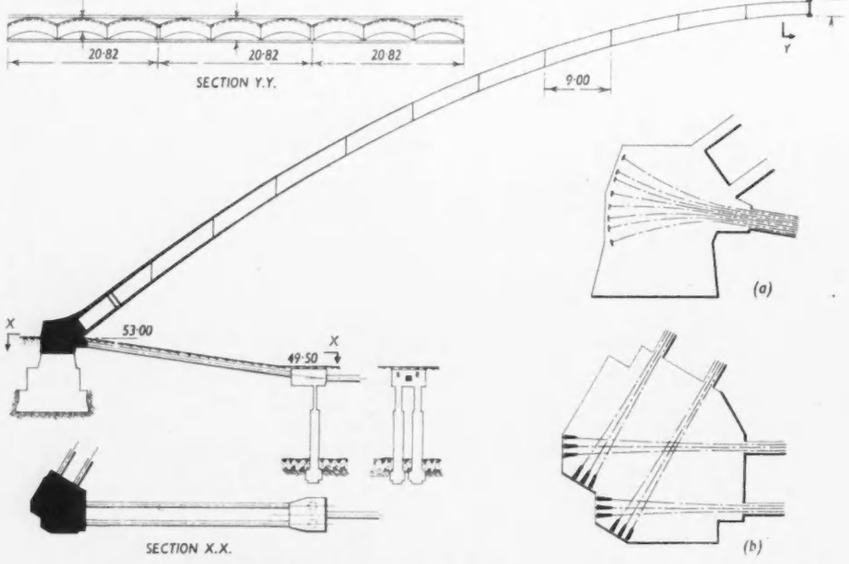


Fig. 7—Sectional elevations of one half of the three cylindrical naves which together form the roof. Note the two parallel, corrugated shells which fan out from the foundations towards the heavy ridge beam, and the cellular structure. Spreading forces at foundations are held by three ties which lie in the vertical planes of the facades. (*a*) Sectional elevation, and (*b*) plan, of post-tensioned cables in these ties: their change in direction requires the use of vertical anchors

tangent to the mid-plane of the vault ; for the central roof section, eighteen 300-tonne jacks were required, i.e. six at each corner. By increasing the thrust of the jacks, the gaps at each root were widened by a calculated quantity, equal to the combined effect of elastic shortening and shrinkage.

At present, the jacks which supported the central section have already been replaced by concrete. The remaining jacks, capable of exerting a total of 18,000 tonnes, will be left in position until the final adjustment of the vault sections is carried out. The resultant side thrust at the top, which amounts to 2000 tonnes between the inner and middle sections, is taken by roller bearings placed in gaps of the crown beams.

Experiments have shown that the creep and shrinkage of the concrete after 110 days, causing a drop of the crown of 85mm, is very nearly the same already as after one year, so that after that time the roof sections could be jacked more or less into their final positions. It is, however, intended to leave the joints open until early next year, when the roof sections will be finally levelled and grouted together, and the jacks will be replaced by concrete. At the same time, the roller bearings will be embedded in concrete.

The scaffolding was moved sideways by fitting rollers under it and knocking out the wedges on which it rested. Special joints had been provided in the middle sections at the level of the top galleries, so that the top portions could continue to be moved outwards over the galleries on which they were supported, while the lower portions were dismantled.

The three tower cranes used in the erection of the roof were mounted on rail tracks on the top galleries, so that their 50m long horizontal jibs were able to cover the whole of the roof except for small parts at the centre and in the corners. These cranes were capable of lifting 1·5 tonnes at full radius. After completion of each roof section, the crane tracks were shifted outwards. Radio transmitters for remote control of the cranes were housed in a temporary building situated on top of the roof at the centre, which also accommodated the instruments for reading eighty-five acoustic strain gauges which were fitted to the roof.

The shuttering for the lower roof shell consisted of plywood forms which were curved to the correct radius. After the concrete had been placed and set, the prefabricated spandrels and webs shown in Fig. 9 were set up and the gaps concreted, the joints in the webs taking the form of stiffening columns. Lastly, the shuttering for the top shell was placed in position. This consisted of fibreboard panels supported on a wooden framework. These shuttering plates were left in position and help to improve the acoustic and thermal insulation. It is of importance to limit the effects of temperature fluctuation. Annual temperature changes cause the roof to rise and fall by about 15cm (3·4mm per deg. Cent.), but differential expansion, snow and wind load combined can also bring about differences in level of up to 15cm.

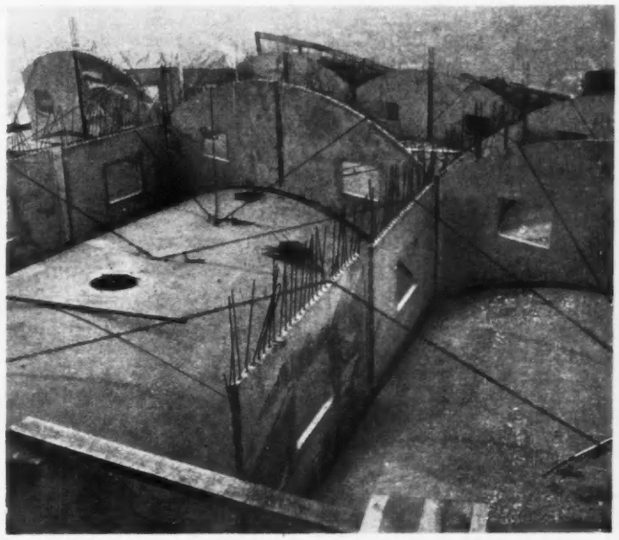


Fig. 9—The roof under construction, showing spandrel walls and webs set up on the *in situ* inner shell. After the concrete forming the joints had been poured and set, the last shuttering for the outer shell (seen in the background) was set up. Note the subdivision of the prefabricated units, the weight of which was limited by crane capacity available to 1·5 tonnes. All of the 1·8m high cells are accessible and holes in the inner shell give access to the ceiling of the hall and allow lighting to be set up

The double shell construction promotes water tightness, which is also improved by the fact that all the stresses in the vault are purely compressive, so that any haircracks will tend to close. There is thus no need to waterproof or coat the concrete. Provision has had to be made to deal with the very large amount of water which the roof is liable to gather in a severe rainstorm, which may amount to 22 cubic metres per minute. To cope with such quantities, storm drains of 1m bore have been laid.

Next to the sweep of the enormous roof, the visitors' eye is attracted by the façades. The three façades are completely glazed, and required a total of 10,000 square metres of glass in the form of ½in thick toughened sheets held in place by screws near the corners. Allowance had to be made for the different thermal expansion of the roof and façades. This was done by supporting the façades on I-section columns which at the upper ends are held by pins sliding in slotted steel channels fixed to the roof, thus permitting the necessary vertical degree of freedom. From beams across the top of these columns, the vertical supports for the glazing are suspended at 2·25m pitch. These, and the cladding which hides the sliding joints at the top, are made of stainless steel. Suspended internal catwalks allow inspection and cleaning of both sides of the glass, the outside being accessible through horizontal gaps resulting from the outward slope at which the panes are fixed.

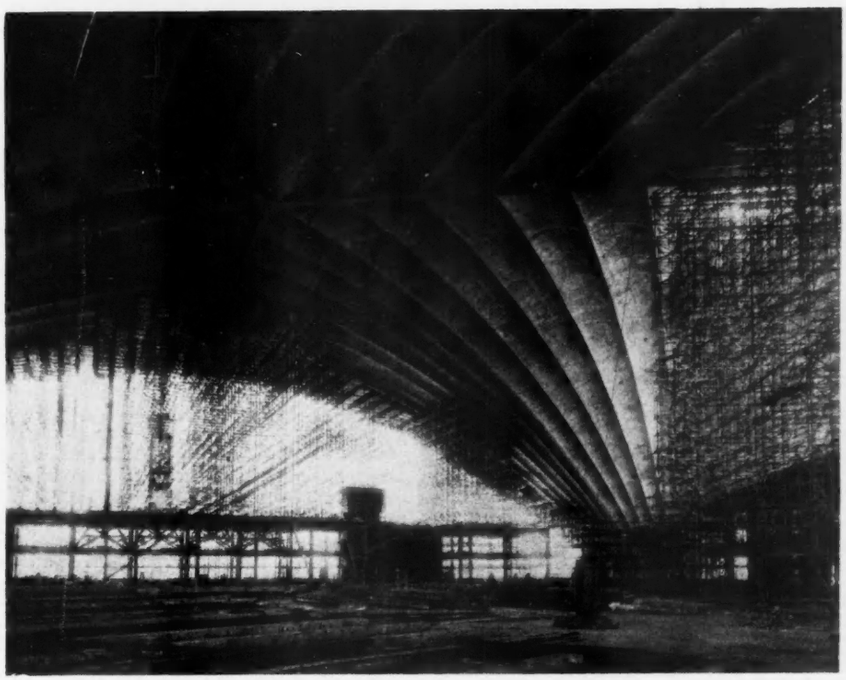


Fig. 8—The partially completed roof from underneath, showing the still separate roof sections (note gap in crown beam), and the scaffolding which was moved on rollers into its new position for concreting the outermost roof sections

Services

In the foundations are 500m of tunnels for installing services : electricity, water, gas, drainage, compressed air and telephone. These services are also to be provided on the upper floors. The internal spaces in the triangular central floor and inside the roof structure facilitate installation of services, in particular of lighting.

The total electrical installed capacity is 15,000kVA, supplied from six similar substations situated at the bottom of the lift shafts. Distribution boards at each level supply low tension at 127V, 220V and 380V. There are four electric circuits on each level : normal, emergency, safety and service.

Heating is by forced air convection ; connection with a district heating scheme planned for Puteaux is envisaged. The exhibition building is to have a 1000-line telephone exchange. There are six 30 h.p. lifts for persons and loads, placed near the double staircases, two at each façade, two service lifts for the restaurants, and one lift serving the administration offices. Escalators may be installed at a future date.

The principal data of the C.N.I.T. are summarised in the table overleaf.

Mechanical Equipment

Large mechanical plant at the site included three "Benoto" hammer grabs for excavating foundations. For the construction of the roof there were three "Weitz" tower cranes of 90-tonne-metres capacity, 30m high and fitted with a special 50m jib, capable of hoisting a 1·5-ton load at the full radius. Three 80-tonne-metres tower cranes of 16m span were employed for placing the prefabricated floor slabs. Other cranes included one crawler-mounted 40-tonne-metres crane, and one 20-tonne-metres auto-crane for placing concrete and for general work. There

Centre National des Industries et des Techniques

No. II—(*Concluded from page* 824, *November* 21)

Inaugurated by the holding of the "Mécanélec 58" Exhibition recently, the Palais des Expositions du Centre National des Industries et des Techniques (C.N.I.T.) is scheduled for substantial completion next year. The groined vault roof of the hall, seen in the aerial view (page 821), *is inscribed in an equilateral triangle with sides measuring* 218*m, and supported at only three points. This structure, unusual in form and in design, constructed in very short time, holds two world records: the longest known span for a shell structure,* 206*m at each façade and* 238*m at the groins—the largest surface supported at a single point,* 7000 *square metres. The floor area totals nearly* 100,000 *square metres. Situated at the Place de la Défense, Puteaux, the projected Concorde-Etoile axis the C.N.I.T. forms the first building of an important development scheme.*

The Roof

SEVERAL design proposals were submitted for the roof; some in concrete, some in steel, and others of a mixed nature. Professor Nervi's design envisaged three ridge beams rising from the corners and meeting at the centre of the roof. From there, a rhomboidal lattice work of reinforced concrete beams, 1·2m deep, and having a module of 3·5m, was to extend outwards, forming three cylindrical naves each at right angles to the corresponding façade. Each lattice section was to be covered by a convex sheet metal roof with metal tie members underneath.

M. Freyssinet proposed a spherical concrete shell roof with three straight vertical façades intersecting the roof. Inside was to be a monolithic, prestressed concrete floor, along the edges of which were to be placed ties to prevent the spread of the dome at the corners. The edges of the vault at the façades were to be supported by vertical cables spaced every metre and prestressed to 9 tonnes. These would also have served as supports for the glazing. The whole was to rest on columns, which in turn were to be seated on pads of synthetic rubber, thereby making possible free lateral expansion and contraction.

Projects envisaging a metal structure also based themselves on the idea of three intersecting cylinders supported between a central spider and a main girder at each façade, or as in Nervi's design, forming a lattice work of beams supported only by the central ridge beams, with a metallic roof.

A mixed steel-and-concrete design deserves to be mentioned. Like the other schemes described, this one also employed a central spider to support three cylindrical naves, which, however, this time were to be in the shape of a double shell of prefabricated triangular concrete elements connected by a lattice of steel tubes.

The project finally adopted was that of Monsieur N. Esquillan, who proposed a double shell roof, also, like some of the other designs, in the shape of three intersecting cylindrical portions, but transmitting its load directly to the three supports at the corners (Fig. 7). From these corners, the elements of the box structure, convex on top and concave underneath, radiate in the manner of a fan, towards horizontal transverse beams at the crown which form a three-armed spider, extending from a common centre in the middle of the roof at right angles to the façades. The box structure is completed by internal webs running out radially from the supports between the corrugations, and spandrels perpendicular to the façades. In front elevation the curve of each cylindrical nave is that of a catenary, so that the forces at each point in the concrete are entirely compressive.

As the sectional view in Fig. 7 shows, each nave of the roof comprises nine equal corrugations arranged in three groups, each of which is 20·82m wide at the crown. The distance between the top and bottom concrete surfaces is 1·8m, and the distance taken over the corrugations amounts to 2·8m. The angular spacing of the webs and corrugations is 3 deg. 20 minutes (one-eighteenth of 60 deg.), and the pitch of the spandrel walls is 9m. This cell structure is of such strength that the thickness of the material can be reduced to a minimum. At the crown the shells are only 6cm thick, and the internal walls are of this thickness throughout. Nearer the corners, the shell thickness had to be increased to about 15cm. For more than 85 per cent of the roof surface the thickness of the shells is equal to, or less than, 6·5cm. It has thus been proved possible to keep the deadweight to the very low figure of 14,200 tonnes without sacrificing rigidity.

For a construction where speed and economy were of such importance, the design proved to be of the greatest advantage. The shells had to be cast *in situ* and the very large amount of tubular scaffolding required to support the shuttering represented a serious problem. If the whole roof had been cast at the same time, some 400km of steel tubing would have been required. As the collection of such a quantity would have been wellnigh impossible, it became necessary to carry out the work in stages, so that the same scaffolding might be used more than once. Another important consideration was the time required to assemble the scaffolding. The mode of construction finally adopted met these points in an extremely neat and efficient manner.

All the three portions into which each nave is divided, as our title illustration (*ante*) or Fig. 8 show, are equal in area and, moreover, are identical in section at each level, and also in plan except for a horizontal lateral "shearing movement," as it were, of the generating section. It was thus possible to use the same scaffolding as well as the same shuttering, for each of the three sections, and to cast the roof in four stages: first, the corners adjoining the previously completed foundation blocks; secondly, the three central sections which were cast in one piece; then, separately, the middle, and finally, the outer sections. The sections, cast at four months' intervals, were kept entirely separate along the whole of their length in order to avoid stresses due to differences in shrinkage and creep.

The mix used contained 350 kg of standard Portland cement per cubic metre of concrete, and design stresses were kept within 100 kg to 130 kg per square centimetre. These stresses, according to the French regulations, require a concrete with a crushing resistance of 130/0·28 —465 kg per square centimetre after ninety days, as measured on test cubes of 20cm side. Although the stresses induced by the dead load alone do not exceed 80 kg per square centimetre, and although the strength of test cubes was already adequate after fifteen days, the shuttering was left in place for twenty-one days before being struck. Studies of creep had shown that deformations are considerably increased if high stresses are imposed on a concrete which is insufficiently aged.

By preassembling large sections on the ground and hoisting them into place by crane, the whole of the roof scaffolding was assembled in two months. The magnitude of this part of the work will be appreciated when it is realised that the centre scaffold portions, which extended from ground level to the underside of the middle of the roof, were about 50m high, while the adjoining sections, which stood on the central triangular floor, were up to 37m high, and the total of steel tubing amounted to 280km. The scaffolding for each nave consisted of five sections on either side of the central vertical plane. A special procedure was adopted to keep the scaffolding intact after each stage and move it laterally into position ready for the next stage. The shuttering was struck by forcing each completed roof section upward by means of hydraulic jacks. These jacks—which were fitted with screwed take-up collars as a safeguard against hydraulic failure—were placed in gaps left between the initially completed common roof section adjoining the foundation blocks, and the individual vault sections. Their line of action was along the

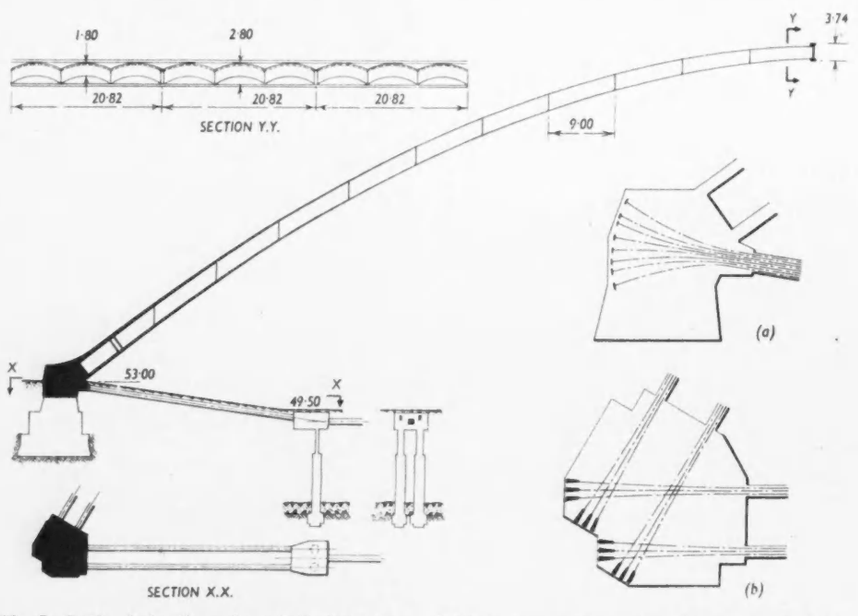


Fig. 7—Sectional elevations of one half of the three cylindrical naves which together form the roof. Note the two parallel, corrugated shells which fan out from the foundations towards the heavy ridge beam, and the cellular structure. Spreading forces at foundations are held by three ties which lie in the vertical planes of the facades. (*a*) Sectional elevation, and (*b*) plan, of post-tensioned cables in these ties: their change in direction requires the use of vertical anchors

tangent to the mid-plane of the vault ; for the central roof section, eighteen 300-tonne jacks were required, i.e. six at each corner. By increasing the thrust of the jacks, the gaps at each root were widened by a calculated quantity, equal to the combined effect of elastic shortening and shrinkage.

At present, the jacks which supported the central section have already been replaced by concrete. The remaining jacks, capable of exerting a total of 18,000 tonnes, will be left in position until the final adjustment of the vault sections is carried out. The resultant side thrust at the top, which amounts to 2000 tonnes between the inner and middle sections, is taken by roller bearings placed in gaps of the crown beams.

Experiments have shown that the creep and shrinkage of the concrete after 110 days, causing a drop of the crown of 85mm, is very nearly the same already as after one year, so that after that time the roof sections could be jacked more or less into their final positions. It is, however, intended to leave the joints open until early next year, when the roof sections will be finally levelled and grouted together, and the jacks will be replaced by concrete. At the same time, the roller bearings will be embedded in concrete.

The scaffolding was moved sideways by fitting rollers under it and knocking out the wedges on which it rested. Special joints had been provided in the middle sections at the level of the top galleries, so that the top portions could continue to be moved outwards over the galleries on which they were supported, while the lower portions were dismantled.

The three tower cranes used in the erection of the roof were mounted on rail tracks on the top galleries, so that their 50m long horizontal jibs were able to cover the whole of the roof except for small parts at the centre and in the corners. These cranes were capable of lifting 1·5 tonnes at full radius. After completion of each roof section, the crane tracks were shifted outwards. Radio transmitters for remote control of the cranes were housed in a temporary building situated on top of the roof at the centre, which also accommodated the instruments for reading eighty-five acoustic strain gauges which were fitted to the roof.

The shuttering for the lower roof shell consisted of plywood forms which were curved to the correct radius. After the concrete had been placed and set, the prefabricated spandrels and webs shown in Fig. 9 were set up and the gaps concreted, the joints in the webs taking the form of stiffening columns. Lastly, the shuttering for the top shell was placed in position. This consisted of fibreboard panels supported on a wooden framework. These shuttering plates were left in position and help to improve the acoustic and thermal insulation. It is of importance to limit the effects of temperature fluctuation. Annual temperature changes cause the roof to rise and fall by about 15cm (3·4mm per deg. Cent.), but differential expansion, snow and wind load combined can also bring about differences in level of up to 15cm.

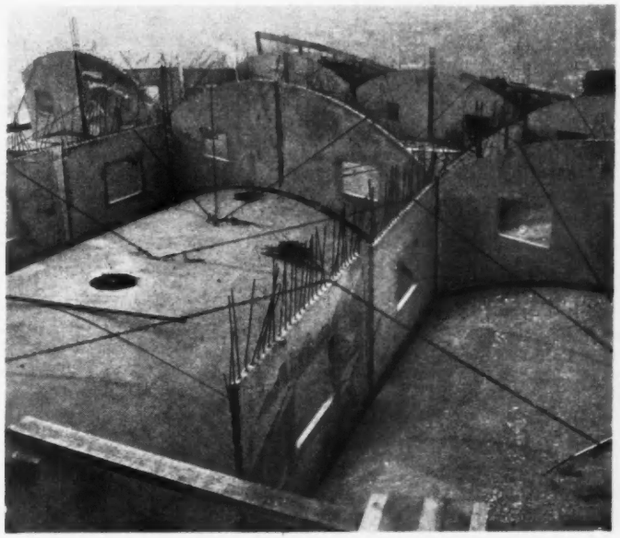


Fig. 9—The roof under construction, showing spandrel walls and webs set up on the *in situ* inner shell. After the concrete forming the joints had been poured and set, the last shuttering for the outer shell (seen in the background) was set up. Note the subdivision of the prefabricated units, the weight of which was limited by crane capacity available to 1·5 tonnes. All of the 1·8m high cells are accessible and holes in the inner shell give access to the ceiling of the hall and allow lighting to be set up

The double shell construction promotes water tightness, which is also improved by the fact that all the stresses in the vault are purely compressive, so that any haircracks will tend to close. There is thus no need to waterproof or coat the concrete. Provision has had to be made to deal with the very large amount of water which the roof is liable to gather in a severe rainstorm, which may amount to 22 cubic metres per minute. To cope with such quantities, storm drains of 1m bore have been laid.

Next to the sweep of the enormous roof, the visitors' eye is attracted by the façades. The three façades are completely glazed, and required a total of 10,000 square metres of glass in the form of ¼in thick toughened sheets held in place by screws near the corners. Allowance had to be made for the different thermal expansion of the roof and façades. This was done by supporting the façades on I-section columns which at the upper ends are held by pins sliding in slotted steel channels fixed to the roof, thus permitting the necessary vertical degree of freedom. From beams across the top of these columns, the vertical supports for the glazing are suspended at 2·25m pitch. These, and the cladding which hides the sliding joints at the top, are made of stainless steel. Suspended internal catwalks allow inspection and cleaning of both sides of the glass, the outside being accessible through horizontal gaps resulting from the outward slope at which the panes are fixed.

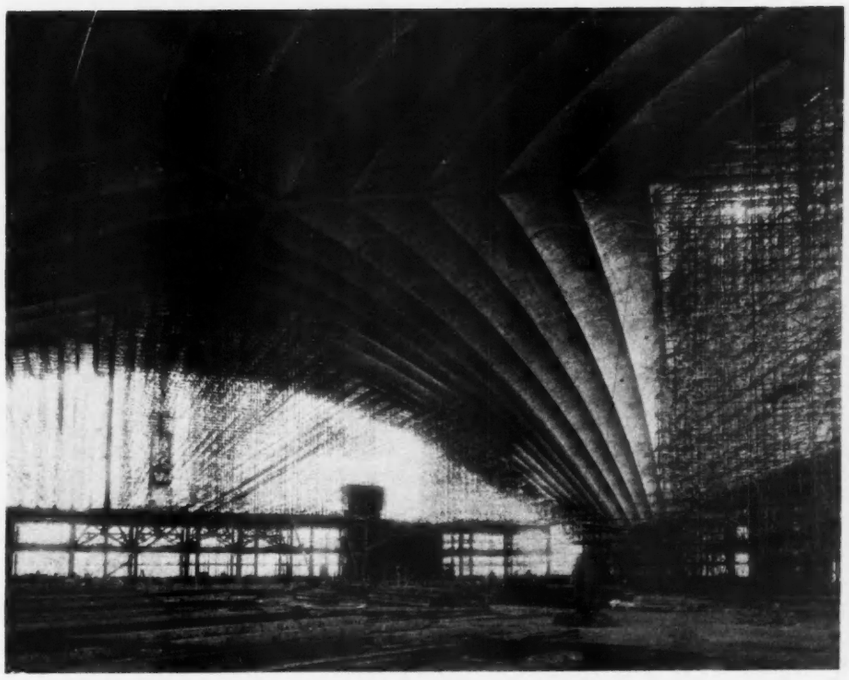


Fig. 8—The partially completed roof from underneath, showing the still separate roof sections (note gap in crown beam), and the scaffolding which was moved on rollers into its new position for concreting the outermost roof sections

Services

In the foundations are 500m of tunnels for installing services : electricity, water, gas, drainage, compressed air and telephone. These services are also to be provided on the upper floors. The internal spaces in the triangular central floor and inside the roof structure facilitate installation of services, in particular of lighting.

The total electrical installed capacity is 15,000kVA, supplied from six similar substations situated at the bottom of the lift shafts. Distribution boards at each level supply low tension at 127V, 220V and 380V. There are four electric circuits on each level : normal, emergency, safety and service.

Heating is by forced air convection ; connection with a district heating scheme planned for Puteaux is envisaged. The exhibition building is to have a 1000-line telephone exchange. There are six 30 h.p. lifts for persons and loads, placed near the double staircases, two at each façade, two service lifts for the restaurants, and one lift serving the administration offices. Escalators may be installed at a future date.

The principal data of the C.N.I.T. are summarised in the table overleaf.

Mechanical Equipment

Large mechanical plant at the site included three " Benoto " hammer grabs for excavating foundations. For the construction of the roof there were three " Weitz " tower cranes of 90-tonne-metres capacity, 30m high and fitted with a special 50m jib, capable of hoisting a 1·5-ton load at the full radius. Three 80-tonne-metres tower cranes of 16m span were employed for placing the prefabricated floor slabs. Other cranes included one crawler-mounted 40-tonne-metres crane, and one 20-tonne-metres auto-crane for placing concrete and for general work. There

TABLE—*Principal Data of C.N.I.T. Exhibition Hall*

Area of site	40,000 square metres	Overall height	51·1m
Area covered by building	27,000 square metres	Area of roof	27,000 square metres
Span along each façade	218m	Area of façades (total)	10,000 square metres

	Exhibition Space	Total Floor Area	Headroom
Level of Avenue Leclerc (ground level)	11,500 square metres	30,000 square metres	9·8m
	1,000 square metres		45m
	11,000 square metres		5m
	2,500 square metres		11m
First floor level	11,500 square metres	18,000 square metres	6m
Level of Avenue Perronet (2nd floor)	7,000 square metres	29,000 square metres	5m
	2,500 square metres		8m
	10,500 square metres		10–35m
First upper gallery (3rd floor)	7,000 square metres	10,000 square metres	5m
Second upper gallery (4th floor)	6,500 square metres	12,500 square metres	5m
Total	71,000 square metres	99,500 square metres	—

Thickness of compound roof shell	1·8m	Steel for prestressed concrete	285 tonnes
Thickness of each shell (near ridge)	6 cm	Total length of scaffold tubing	350,000m
Earth movement	100,000 cubic metres	Scaffold tubing for roof only	280,000m
Volume of concrete	37,000 cubic metres	Weight of roof	14,200 tonnes
Portland cement	13,500 tonnes	Snow load allowed for	1,200 tonnes
Aggregate	80,000 tonnes	Timber shuttering	3,000 cubic metres
Steel for plain reinforced concrete	2,930 tonnes	Prefabricated concrete elements	27,000 tonnes

were four 25 h.p. tractors with semi-trailers for transporting prefabricated elements from the Pont de Bezons plant to the site, and three 3 cubic metres mixer trucks for carrying concrete mixes prepared at the plant either dry for mixing at the site, or mixing them *en route*. In addition there was the usual contractors' equipment. A material testing laboratory and a research centre for doing research in connection with the roof were erected. The total electrical capacity of the equipment at the site was 1050kW.

Batching and Prefabrication Plant

Since space at the site was insufficient, concrete batching and the manufacture of prefabricated units was carried out at a plant, specially constructed in only four months, at the Pont de Bezons, about 4km away on the River Seine. This arrangement allowed aggregate to arrive by barge, for the unloading of which there was a 40-tonne-metres rail-mounted crane. Cement was received in containers by rail. Mixes for use at the Rond-Point were batched and either mixed *en route* or after arrival.

For prefabrication, an 1800 square metres plant and a 3300 square metres storage yard were provided, equipped with two travelling cranes, four mono-rails for the concrete and one travelling portal crane. The electrical installation amounted to 960kVA. A total of some 40,000 tons of prefabricated components were manufactured. In an annexe, reinforcements and prestressing cables were produced. About fifty men were employed.

The concrete units made ranged from 3 to 6 tons, their size being limited by the requirements of road transport and the capacity of the cranes at the site.

The moulds were constructed according to the system evolved by Constructions Edmond Coignet. They were of steel and had a central steam or hot water jacket. The outer walls were hinged-on at the bottom and could be opened or closed by hydraulic jacks ; abutting faces were machined. Following initial curing of the casting, the mould was opened and the component raised clear by a further set of hydraulic jacks. After attaching the crane tackle, the load could very gently be transferred without jerks by slowly lowering the jacks.

Principal Contractors

For executing the design work and controlling the construction, the Société de la Défense (SOCODEF) was formed. Under its direction, the principal contractors carried out their task. The main structure was in the hands of the Groupement des Travaux de la Défense (GETRADEF), an association of the firms Balency and Schuhl, Boussiron, and Coignet.

Aluminium Cable Sheathing Press

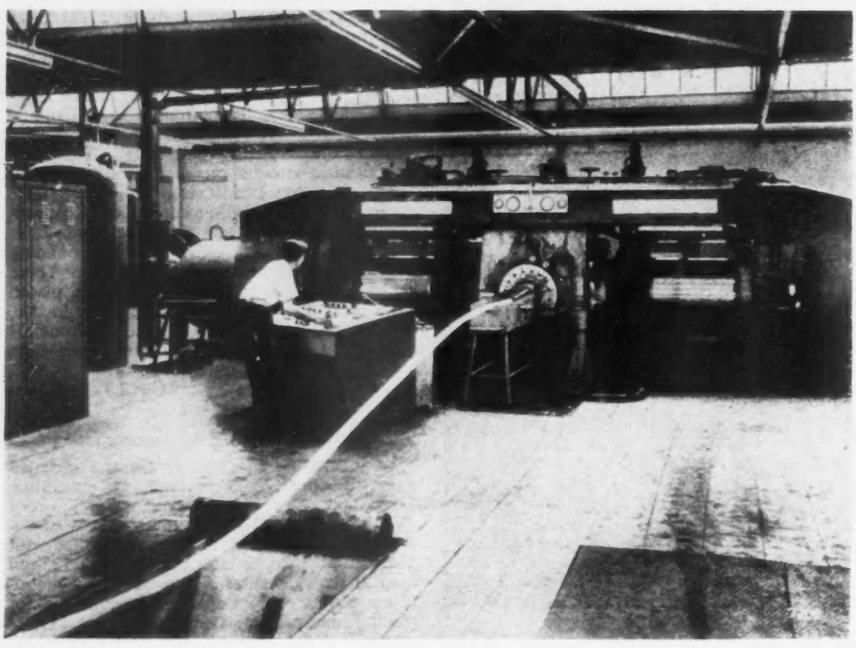
The advantages of aluminium cable sheaths—low weight, high compression strength, tensile strength and fatigue resistance, as well as good conductivity—gave rise to the development of a double-acting, horizontal, aluminium cable sheathing press, which meets the technical and economical requirements of the cable industry. This press permits the manufacture of cable sheaths of pure aluminium (99·5 to 99·8 per cent) of any desired length up to an outside sheath diameter of 100mm ; the sheaths may be extruded both on to cable core with plastic insulating materials sensitive to heat and on a dry or impregnated dielectric. Besides its use for cable sheathing, the press can be employed for the extrusion of wire rods, sections and tubes of pure aluminium.

In January, 1957, the first plant of this design commenced production in the United States. Another press has been in operation in Germany since December, 1957. The makers—Schloemann Aktiengesellschaft Düsseldorf—are at present erecting three further presses in France, Norway and Germany ; another four plants are in the course of manufacture.

The plant consists of a 1600-ton aluminium cable sheathing press (shown in the accompanying illustration), two induction furnaces with switchgear, and a pressure oil station, comprising a pump unit and an oil-hydraulic accumulator.

The main problem when developing this process was to avoid the possibility of burning the sensitive cable insulation during the stop periods required for entering new billets. Heat protective and spray devices were therefore designed which, it is stated, preclude damage by heat. The thickness of the cable sheath can be adjusted during operation of the press by means of a hydraulically actuated ratchet key. This is necessary because while introducing fresh billets, a lessening of the sheath diameter results through contraction of the die caused by the temporary relief in pressure. Suitable adjustment of the ratchet key compensates for this, and even makes it possible to provide such sections with additional mechanical strength by somewhat increasing the wall thickness above the average. Adjustment of the contraction area, also called " bamboo ring " or " stop mark," can now also be done automatically.

Two billets, each of 175mm diameter and 440mm long, and weighing 27·5 kg, are extruded simultaneously at a temperature between 450 deg. and 500 deg. Cent. Entry and delivery of the cable are at right angles to the press centre line. Depending on the tools used, cable from 5mm to 60mm, 5mm to 800mm or up to 100mm outside diameter can be sheathed.



Delivery side and control desk of 1600-ton aluminium cable sheathing press

Fédération Européenne de la Manutention

Section II (Continuous Conveying Equipment) of the Fédération Européenne de la Manutention held meetings in Ostend on October 14 and 15, 1958, on the occasion of the European Congress. The first volume of the International Terminology of the Section, containing line diagrams and nomenclature of the principal equipment in seven languages, is expected to be published at the beginning of the new year. The second volume of the Terminology will feature the various component parts of conveying units and will be published in loose-leaf form at a later date. Other aspects which have been under study are the Universal Decimal Classification, a European Classification of Materials, many aspects of standardisation on a European level, safety regulations, and the establishment of a table of working equivalents for imperial and metric systems of measurement. A permanent technical secretariat has been created. The next meetings of the section will be held in Nice on March 18, 19 and 20, 1959.

Electrical Typewriter With Perforated Tape Mechanism

It is announced by Triumph Werke Nürnberg A.G. that it is putting on the market a combined electrical typewriter and ticker-tape machine which, it is stated, finds applications not only to telecommunications, but also to office management and production techniques (preparation of punched cards). Typing can be carried out either in the normal manner or, by operating a switch, can be combined with the simultaneous production of a perforated tape punched in the standard teleprinter code, which can then be used for the mechanical transmission of a message at 400 letters per minute, twice the speed of manual teletyping.

The American Scene

BY OUR AMERICAN EDITOR

Surplus of Nickel

In the course of the past year, the International Nickel Company of Canada, the world's major producer of nickel, several times cut its output of the metal, while other smaller producers closed down their mining operations altogether. Recently, I.N.C.O. distributed thousands of copies of a statistical study entitled "The Supply of Nickel, 1958–1961," to explain the reasons behind those cuts, and to assure North American users of the availability of a generous supply of nickel for many a year to come. All these events symbolise an enormous change in the market for this once extremely scarce metal. What long has been looked upon as the last of the major wartime shortages has turned into a conspicuous glut. The turn-about results not only from a sharp shift in market conditions, but also from some persistent mistakes in the recent policy of the U.S. Government. For years, Washington overstated the demand for the metal and brought about an over-expansion of productive capacity. Now, with additional facilities still coming in, the world's producers, old and new alike, have entered a long and difficult period of over-supply. For the first time in nearly two decades, the nickel industry faces the hard task of fighting to expand its market.

In recent years the shoe has been consistently on the other foot. After World War II, nickel continued to pour into ships, tanks and guns to safeguard America's future military preparedness; it also flooded back into a wide range of civilian uses. And still demand continued to grow. When war broke out in Korea, nickel enjoyed that final accolade of scarcity, a black market, in which consumers paid as much as 2·75 dollars a pound for it, compared to its legitimate price of 74 cents. Government officials, meanwhile, encouraged potential users to find ways of getting along without the metal. Even I.N.C.O. sometimes went as far as to help its customers in the search for substitutes. Strangely enough, however, this persistent shortage arose not in the market-place, but in the Office of Defence Mobilisation and its sister agencies in Washington. Between 1951 and 1957, for example, even while consumers were paying premium prices, actual nickel deliveries were exceeding consumption year after year. This little-recognised surplus was achieved despite the fact that the use of the metal meanwhile was increasing by more than one-half. For the whole seven years, total supply exceeded consumption by 339 million pounds. Most of this metal was swallowed up by an ever-growing U.S. stockpile. The latter in turn grew out of the federal planners' greatly exaggerated ideas about the wartime need for nickel. Only last year were those ideas finally, and belatedly, revised. While it lasted the supposed shortage inevitably had major effects on the industry. By last year, the effects of this process had become unmistakably clear. In the words of Dr. John F. Thompson, the chairman of I.N.C.O.: "The market for nickel started the year 1957 with an over-demand so substantial that some customers continued to pay premium prices to obtain the supplies they urgently needed. It ended with nickel in over-supply." Several forces combined to bring matters to a head in 1957. Not only did new capacity come in, but marked declines also occurred in demand. The unusually depressed state of the steel and automotive industries, the two biggest civilian consumers of the metal, weakened the market. Defence needs, too, were reduced sharply. Looming above all in importance was the Government's decision to stop stockpiling, and to release to private industry much of the nickel that was scheduled for delivery to Uncle Sam under long-term contracts, at generous prices. This combination of factors had a sledge-hammer effect on the nickel market—an effect which is still continuing.

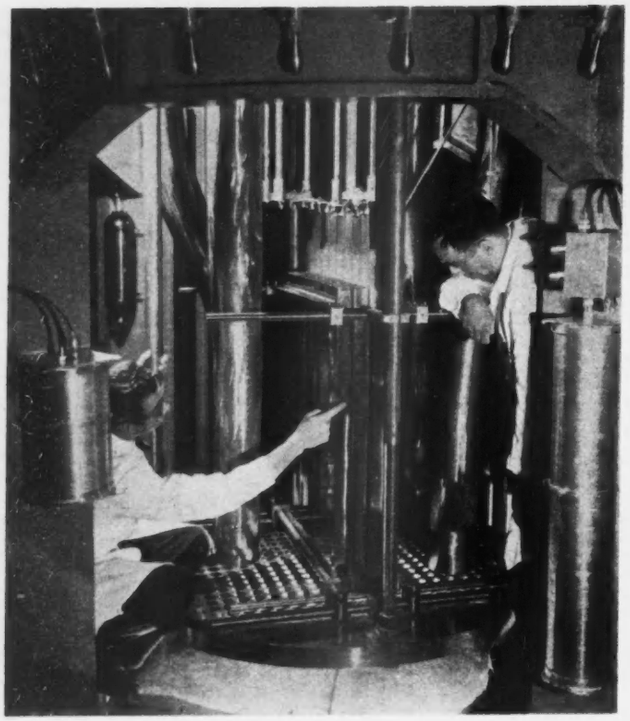
In spite of these mounting problems, however, the wheels of expansion, once set in motion, could not be stopped. Even now, the industry stands committed to a further 40 per cent enlargement of its capacity over the next three years. I.N.C.O. itself, for example, is continuing the development of its new find in Manitoba, which was begun late in 1956 and is scheduled for completion in 1960. By the following year, the company estimated it will be able to produce 75,000,000 lb annually, making this the world's second largest single source of supply. Other producers, too, are going ahead with their plans. By 1961, unless present plans are modified, the free world may be producing some 689 million tons of nickel a year. That would represent a rise of 200 million pounds from the amount delivered in 1957, and of 277 million pounds from the total actually used. What is more, the capacity due to be reached within the next three years will be no less than double to-day's consumption. Confronted with this dreary supply-and-demand picture, what do the nickel producers propose? Despite all their present woes, it is worth noting, they are not wholly without resources. For one thing, nickel is a remarkable metal—if a relatively expensive one. Certain of its historic uses to-day are declining. In the "Space Age," however, the metal seems likely sooner or later to achieve a come-back, particularly as an alloy. Already there are many hints of things to come. The U.S. Army's successful "Explorer" satellite, for example, mounts a nose cone of thin nickel-bearing stainless steel. Similarly, the entire protective skin of the "Atlas" is made of an iron-nickel-cadmium alloy. The low-temperature propellant tanks for the "Bomarc" missile and the "Vanguard" rocket consist of a nickel alloy. Stainless steel is used, too, to fabricate the skin, wings, protrusions, controls, wires, plumbing and actuators of North American Aviation's "X-15" rocket aircraft. On the distant horizon, then, are a host of important uses for this metal. Expanding its military uses, however, will be a long-range job. The more immediate challenge is to enlarge the civilian markets for nickel. Here the producing companies must reverse their entire approach of the past two decades. After all those years of real or apparent short supply, it is a major effort to sell potential consumers on the idea that nickel finally is available in quantity, now and for the future. Getting this message across will take considerable time. In recent years, for instance, many American companies gave instructions to their designers and engineers limiting or actually prohibiting the use of nickel.

The nickel industry is girding itself, nonetheless, to expand its existing markets and, at the same time, create new ones. The first target of International Nickel is its biggest customer, the steel industry, which accounts for about 40 per cent of the nickel market. The emphasis here is on stainless steel, which alone takes about 25 per cent of all nickel. For example, the company is working with the American Steel Warehouse Association on a campaign to promote the sale of alloy steels by the warehouses, which have been selling about 17 per cent of all alloys. I.N.C.O. intends to concentrate on two "universal" stainless alloys, and will attempt to persuade the warehouses to cut the number of grades they carry. Naturally, the company is eager to get them to drop the non-nickel-bearing grades of stainless steel, which have made headway during the supposed shortage. At the same time, I.N.C.O. has begun a comprehensive study of the nickel-plate market, which it hopes to recapture. During the shortage, nickel plating for automobile bumpers, for instance, shrank to a third of its former thickness. That made a rather unsatisfactory product and opened the door to aluminium. The trend now is being reversed, but under practical difficulties that are illustrative of many others facing the company. The thickness of the plating normally is determined by the length of time the bumper is in the plating bath. If that time now is lengthened, it threatens to slow down an entire assembly line. Until that hurdle is overcome, nickel may have trouble regaining this particular market. Yet I.N.C.O. is hopeful that it can surmount such barriers. The average American car to-day embodies about 5½ lb of the metal, and lorries substantially more. Obviously, any increase in automotive use of nickel is important. Great hopes, therefore, are placed in the development of gas turbine engines for motor vehicles, which might more than double that use. The nickel producers also hope that sooner or later Detroit will adopt the nickel-cadmium storage battery. Up to now, this has been used chiefly on railways, in lift trucks, in military applications, and in hearing aids. Its great virtue is long life, its drawback a cost about triple that of conventional lead-acid batteries. I.N.C.O. has high hopes of getting it accepted first for use in Cadillacs. Since each battery would require about 20 lb of nickel, success here would be of major significance.

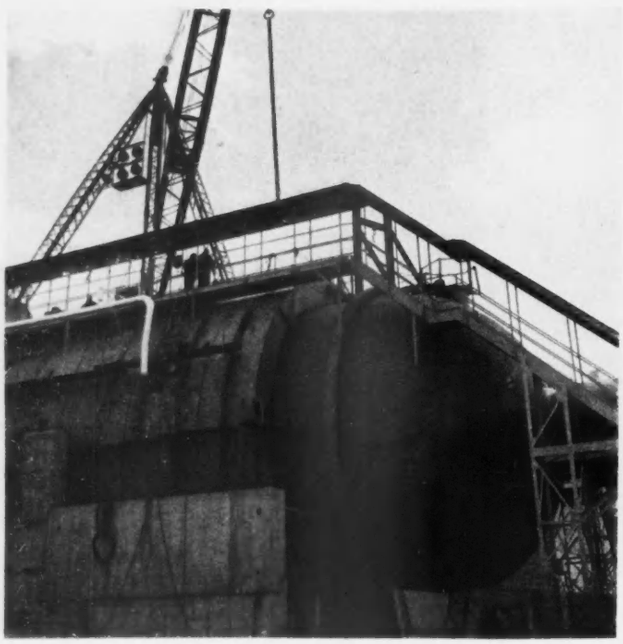
All these uses, actual and prospective, offer a considerable measure of cheer to those nickel producers who can afford to take the long view. They do, however, require a basic change in marketing technique for an industry which for many long years has prospered because of shortages, real or Government-induced. As the companies themselves are the first to admit, this about-face will take long months of weary effort. For the very long run, the outlook for nickel is as auspicious as ever. Between now and 1961, however, all the industry's efforts to carve out new markets are most unlikely to keep pace with its increasingly mountainous over-capacity.

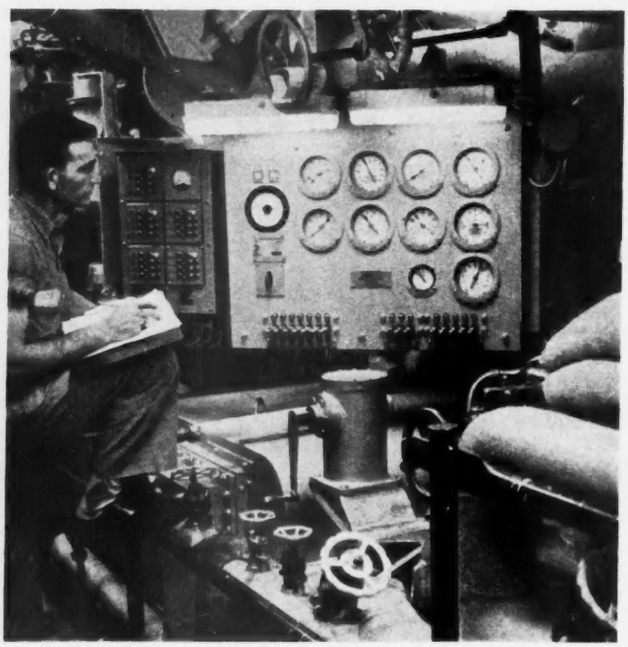
Land-Based Prototype Propulsion System for Nuclear Submarine

The photographs reproduced here show the land-based prototype propulsion system for the U.S. Submarine "Triton" which is now operating in a hull section at West Milton, New York. The unit was developed for the U.S. Atomic Energy Commission by the Knolls Atomic Power Laboratory of the General Electric Company and is believed to be the first twin-reactor ship propulsion system. Both reactors are cooled and moderated by pressurised water. While most details of the reactor design are classified, the following facts have been released. Higher shaft horsepower is developed by each reactor than by any other existing submarine power plant. The plant has lower weight per shaft horsepower than any other existing nuclear submarine propulsion unit. The plant uses the most compact core of water-cooled reactors of any submarine launched. The new twisted ribbon fuel elements offer the possibility of increased heat transfer efficiency over plate-type elements and of lower manufacturing costs. A unique arrangement of separate unit cells is used to make up the reactor core. In-hull refuelling is facilitated by unit-cell construction: refuelling access is through a small hatch in the hull. A saving of about four weeks is obtained in refuelling time over earlier nuclear submarines: refuelling at a sea anchorage is made possible by the in-hull refuelling system. Mass production methods can be applied to the fuel elements and the unit cells. Either one or two reactors can be used for the operation of the ship.



The illustration ABOVE shows the interior of submarine hull with steam turbo-generator for auxiliary power supply on U.S.S. "Triton." Illustrated LEFT is the Proof Test Reactor (PTR) of Knolls Atomic Power Laboratory used in the development of reactor components for the "Triton." The third illustration, BOTTOM LEFT, shows the hull section housing the prototype twin nuclear reactor plant at West Milton, New York. The fourth illustration, BELOW, shows the control station of the propulsion plant in the land-based hull section.





Direct-Chill Casting of Copper and Copper-Base Alloys

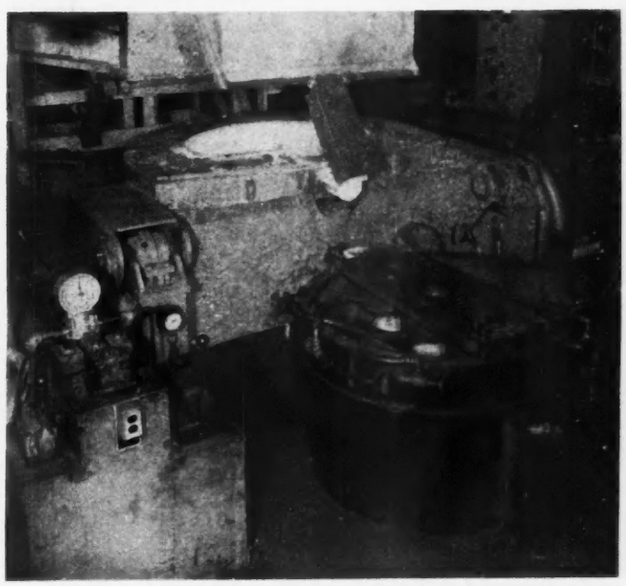
RECENTLY published statistics have shown that in the American aluminium industry 90 per cent of all extrusion billets, rolling mill slabs and wire bars are produced by direct-chill continuous or semi-continuous casting methods. This figure is all the more impressive when one considers the fact that this development has taken place in the comparatively short period of time since the end of World War II. By comparison, the red metals industry shows the exact reverse of the above statistics for copper-base alloys; 90 per cent of all billets, slabs and bars produced by shell moulds of one type or another, and only 10 per cent of total American production resulting from continuous casting methods. On the other hand, European mills long ago adopted continuous and semi-continuous casting methods for the production of red metals. Starting with the original development by Junghans in 1932, many of the leading producers of brass, bronze and copper throughout Europe to-day cast most of their billets and slabs by direct-chill production methods.

Considering the obvious advantages of the direct-chill continuous casting method, it is all the more surprising that the technique has not been embraced by the American red metals industry with even greater enthusiasm than by the light metals industry. The causes for this reticence have been partly founded in the lack of efficient and comparatively inexpensive casting equipment and the lack of information concerning continuous casting techniques for red metals and alloys. With the recent development of the "Lobeck" direct-chill casting equipment in America, simple, efficient and inexpensive semi- and fully continuous casting machines are now available to even the smallest independent producer. Hydraulically operated, mechanically simple, requiring little space and run by a single operator, these machines have a production capacity far beyond that of any shell mould system. Casting multiple strands either fully continuously or semi-continuously up to 25ft long, the metal gate loss is less than 1 per cent and the resulting casting is of the highest metallurgical quality. The surface finish, too, is far above that obtainable with a shell mould.

The most critical part of a continuous casting system is, of course, the mould itself. Here, perhaps more than in any other phase, recent developments have brought great progress. New mould designs, new mould materials and revised theories of heat exchange between mould interface and cooling water are permitting ever-increasing speeds while maintaining the high surface and structural qualities of the castings One of the most vexing problems in the casting of copper-zinc alloys has been the formation of a heavy coating of zinc oxide on the surface of the mould. Caused by the evaporation of metallic zinc during the pouring and the subsequent condensation of this zinc vapour as zinc oxide on the mould interface, this oxide layer becomes so heavy as to impede the flow of metal from the mould and finally tears from the mould, leaving the mould surface marred and the surface of the casting so encrusted as to cause that segment to be rejected. This is emphasised to an even greater extent if the alloy system contains lead which may be carried along in vapour form by the zinc and re-deposited in a similar manner on the mould casting interfaces.

To overcome this problem, modern continuous casting machines have provisions for oscillating their moulds, thus preventing the build-up of the zinc oxide, depositing it as a fine film evenly over the casting surface and giving the casting a smooth, uniform appearance. No longer need there be any metal loss due to surface imperfections. Neither is there any need for continuous mould maintenance and replacement because of internal marring. In the casting of pure copper and high copper content alloys, gaseous contamination has been eliminated by the use of new mould materials. No longer is it necessary to use organic lubricants in the moulds and thus introduce a potential oxygen-producing substance into the very place from which one would like to eliminate it. To-day's moulds for the production of oxygen-free copper are self lubricating, using an inorganic interface. The atmosphere within the mould can be rendered inert by the use of metallico-chemical additives. As a result, the cast billet or slab meets the most rigid specifications controlling gas content.

In the continuous casting of extrusion billets (Fig. 1), be they of the copper, brass, bronze, or copper-nickel group of alloys, almost all of the casting problems have been solved. Diameters as low as 3in and as large as 15in are now being cast on a production basis and in any desired length. Besides the regular, solid billet, the case for the hollow billet, which permits the extrusion of larger diameter shapes without the proportionate increase in extrusion pressure, is becoming stronger every day. Hollow billets, cast by means of a cooled mandrel, are cast in all sizes, their only limitation being a mechanical one which requires the wall thickness to be sufficiently large to permit the introduction of the pouring spout between mandrel and mould. An added advantage of the continuous casting method for the producer of extrusion billets lies in the fact that the billet length can be varied in accordance with individual die requirements, thus eliminating random lengths of extrusions with large percentages of excess scrap.



Semi-continuous direct-chill casting machine for the simultaneous casting of three copper-base alloy extrusion billets

When attempting to produce rolling mill slabs of various sizes and dimensions by continuous casting methods (Fig. 2), basic differences in the geometry of the casting pose different problems. Extrusion billets and wire bars, by being round and square respectively, offer a uniform perimeter and therefore have a uniform cooling rate throughout their cross section; this does not apply to rolling mill slabs which are rectangular in shape. Here the adjacent sides of the rectangle, controlling thickness and width of the slab, have different cooling rates. It is this difference in the cooling rate which causes certain limitations in the size of the slab to be cast. Experimentally, it has been determined that for optimum results the ratio of thickness to width should be kept below 1 : 6 in thickness ranges up to about 5in. When the thickness of the slab is increased to above 5in, the thickness to width ratio may be increased to 1 : 8. The greater thickness of the slab results in slower cooling of the "short" direction, approaching the cooling rate of the "long" direction. The limitations pointed out above regarding the casting of hollow billets apply also to the casting of rolling mill slabs of minimum thickness. Here, the width of the slab must be sufficient to permit the introduction of the pouring spout between opposite mould interfaces.

The size tolerance in as-cast continuous and semi-continuous billets, bars or slabs is $\pm 1/32$in, and 90 deg. corners have been achieved. The surface finish of billets and slabs is of such high quality as to require no scalping, grinding or machining of any kind. Close control over and fine adjustment of metal temperatures, casting speeds and cooling rates enable the operator to vary the grain structure and orientation of the castings. Depending upon the ultimate use of the castings, every combination from a fine, dense, homogeneous grain structure distributed evenly throughout the casting to a coarse, heterogeneous structure can be obtained. In some cases, a combination of the two structures, showing a fine dense grain around the periphery with a larger structure at the core of the casting, is produced to obtain maximum flexibility in the subsequent working of the casting.

Looking into the economics of continuous casting methods compared with conventional shell mould casting, one sees as encouraging a picture as one may hope to find. Because the continuous method permits somewhat lower casting temperatures, there is less zinc loss due to volatilisation, the possible difference in this rate of volatilisation being as great as 1 per cent of the total zinc content, or a saving of 20 lb of zinc per ton. Gate loss is reduced to a minimum due to the complete absence of "piping"; it usually amounts to only 1 per cent for semi-continuous casting and even less than that for fully continuous casting. Due to the fast cooling rate, there is no tendency towards segregation of the alloying constituents, avoiding all the subsequent difficulties which segregation usually entails in the extrusion press and rolling mills. In direct relationship to this greater uniformity of the metal as cast is a need for less frequent analysis.

The cost of operating a continuous casting plant compares most favourably to that of the conventional melting shop. The cost of running the machine drive itself is insignificant, the cost of the moulds on a "per pound of metal produced" basis is very small, as is the need for capital investment in spare parts and supplies. Since a direct-chill casting machine requires only one operator, even for multi-strand casting, the savings in direct labour, again on a "pounds produced per man-hour basis," are astounding. Thus, looking at the overall picture presented by the many advantages—both technical and economical—of the direct-chill continuous and semi-continuous casting methods, one can readily understand the present great interest in this method in America and the future potential it offers to the integrated producer of heavy non-ferrous metals.

Personal and Business

Appointments

MR. D. F. WARD has been appointed to the board of directors of Barlow-Whitney, Ltd.

MR. F. A. FIELD has been appointed general sales manager of Firth Cleveland Tools, Ltd.

ADMIRAL SIR RALPH A. B. EDWARDS has been appointed a director of Elliott Bros. (London), Ltd.

HANDY ANGLE, Ltd., has announced that Mr. A. F. Alvers has been appointed assistant home sales manager.

MR. W. DUCKETT has been appointed manager of the Midlands area depot of Easterbrook, Allcard and Co., Ltd.

VICKERS, Ltd., announces that Sir Leslie Rowan and Mr. R. D. H. Yapp have been appointed directors, with effect from December 8.

THE GOODYEAR TYRE AND RUBBER COMPANY (GREAT BRITAIN), Ltd., announces that Mr. T. F. Minter has been appointed manager of its Scottish plant at Garscadden, Glasgow.

LANDMASTER, LTD., announces that Mr. J. H. Smeddle and Mr. M. M. Monfort have been appointed export executives, and Mr. T. Rennison has been appointed commercial manager (export).

LONDON TRANSPORT announces that Mr. A. Readman, A.M.I.E.E., has been appointed principal executive assistant with the title of testing superintendent in the department of the chief electrical engineer.

THE HAWKER SIDDELEY GROUP, Ltd., announces that Mr. A. Sewart has been appointed assistant general manager (missiles), and Mr. R. W. Ward, chief development engineer, of Avro's weapons research division.

MR. R. S. SIMPSON has been appointed manager of the north-west region of the British Institute of Management in succession to Mr. A. D. Ashley. Mr. H. Mc. N. T. Reith has been appointed manager of the southern region.

STENNERS OF TIVERTON, Ltd., has announced that Mr. T. A. Stodart, joint managing director, will relinquish his directorship of the company at the end of the year. Mr. R. J. Piercey, A.M.I.Mech.E., has been appointed works manager and chief engineer. Mr. F. H. Worrall has been appointed technical sales engineer and service manager, and Mr. J. Mills, general technical executive. Mr. W. F. Authers will be sole managing director of Stenners and the associated engineering companies of the Heathcote group.

Business Announcements

BRITISH INSULATED CALLENDER'S CABLES, Ltd., announces that the telephone number of its Nottingham branch office has been changed to Nottingham 55932 (2 lines).

BLACKBURN AND GENERAL AIRCRAFT, Ltd., announces that it has formed a new organisation, at Brough, under Dr. Harry Fuchs, to design and manufacture electronic equipment commercially.

STURTEVANT ENGINEERING COMPANY, Ltd., Southern House, Cannon Street, London, E.C.4, has created within its central organisation a cathodic protection department headed by Mr. J. H. Morgan.

ARMSTRONG WHITWORTH (METAL INDUSTRIES), Ltd., has appointed Hadleigh Seaborne, Ltd., Solihull, Birmingham as its agent for the sales and servicing of "Kue-Ken" jaw crushers in North Wales.

PHILPLUG PRODUCTS, Ltd., has amalgamated with Expandite, Ltd. Mr. T. W. Greenwood remains as managing director of the company. Mr. T. Pooley, Mr. A. Cathcart and Mr. C. R. Warr have been appointed directors of Philplug Products, Ltd.

SIMON-CARVES, Ltd., announces the establishment of a new department to build plants for complete gasification, gas reforming, ammonia synthesis, and the production of nitrogenous fertilisers and certain types of petro-chemicals. The department is under the management of Dr. A. J. Payne.

WEST INSTRUMENT, Ltd., is to open a London office on January 1, 1959. Mr. L. M. Collyer and Mr. N. J. Riddett have been appointed area managers, responsible for West Instrument sales and service in London and the home counties. It has been agreed that as from January 1, 1959, West sales and service will no longer be handled by Industrial Instruments, Ltd.

SIEMENS EDISON SWAN, Ltd., states that subsidiary companies of the former Siemens Brothers and Co., Ltd., in Australia, Canada, Central Africa and South Africa have changed their names. Siemens (Australia), Pty., Ltd., becomes Siemens Edison Swan (Australia), Pty, Ltd., Siemens Brothers (Canada), Ltd., becomes Siemens Edison Swan (Canada), Ltd., Siemens Brothers Central Africa (Pvt.), Ltd., becomes Siemens Edison Swan Central Africa (Pvt.), Ltd., and Siemens Brothers British (Pty.), Ltd., becomes Siemens Edison Swan (Pty.), Ltd.

Contracts

W. H. ALLEN, SONS AND CO., Ltd., announces that the company has received contracts from Vickers-Armstrongs, Ltd., to supply the generating plant for the Orient liner "Oriana" and for the liner building for Canadian Pacific Steamships, Ltd. The plant for the first ship will consist of four 1750kW pass-out condensing turbo-generators and two 200kW diesel-driven generators and that for the second will include two 1500kW condensing turbo-generators and three 500kW diesel-driven generators.

Miscellanea

CORRECTION.—Our issue of November 21, page 810, included a brief account of the electronic wheel truing machine exhibited by Phillips Cycles, Ltd., at the 1958 Cycle and Motor Cycle Show, Earl's Court. We learn that we were advised incorrectly as to the performance of this machine; the average wheel produced is true to within 0·03in.

OBITUARY.—We record with regret the death of Mr. Frederick Seymour Whalley, which occurred at Marlow on November 17. Mr. Whalley, who was seventy-three, was a past-president of the Institution of Locomotive Engineers, and was for some years managing director of The Vulcan Foundry, Ltd., and chairman of Robert Stephenson and Hawthorns, Ltd. . . . We also note with regret the death, on November 14, of Mr. Frank Rutland Stagg, M.I.Struct.E., at the age of seventy-seven. He was deputy-chairman of Thos. W. Ward, Ltd., Sheffield, and had been in the continuous service of that company for over sixty years.

MORE LIGHT FROM COLD CATHODE TUBES.—Recent improvements in phosphor processing have resulted in higher efficiencies for "Osram" cold cathode tubes (9ft 6in overall length, 20mm diameter), made by The General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2. The company states that light output has been increased by up to 10 per cent; in the warm white colour for example, the average efficiency throughout life has been raised from 37 to 41 lm/W. At the normal tube current of 120mA the power dissipation is approximately 67·5W, to give a total light output of 2770 lm for this colour. Similar increases are now effective for all other colours in the range, and in no case is there any reduction in tube life.

TRAINING YOUNG SCIENTISTS.—To help meet the national shortage of scientists and to assist science teachers, the British Broadcasting Corporation is prepared to expand its present television schools programmes. The Director General of the B.B.C., Sir Ian Jacob, told the School Broadcasting Council on November 7 that if there was a national need, the B.B.C. was a national institution, with a duty of filling it. Sir Ian said that the president of the Royal Society, the president of the British Association and the chairman of the Advisory Council on Scientific Policy had called on him recently to urge that the B.B.C. should do its best to interest people in science. The B.B.C., he said, proposed "to put all the resources it could behind this job, which it was already doing." The B.B.C., Sir Ian added, was well placed to expand its present experimental television service to schools, but television cost six times as much as sound. Given the money, channel space and support from the educational authorities, however, the B.B.C. was ready to increase its already great effort for education.

POTASH FROM JORDAN.—About 1000 men, under the supervision of L. H. Manderstam and Partners—consulting engineers, 38, Grosvenor Gardens, London, S.W.1.—are employed at present at the north end of the Dead Sea. Their immediate tasks are to rehabilitate the area designated for carnallite solar pans and the construction of a pilot plant for the production of potash. The pans and installation previously operated by the Palestine Potash Company were destroyed by the Arab armed forces during the Palestinian war. The area was ravaged to such an extent that levelling of the ground before construction of the pans has become essential. The installation and operation of the pilot plant is intended mainly for collecting data on new processes and techniques, which will be applied on a pilot scale. An initial survey of the soil of the area selected for the construction of solar pans, showed that it is heavily contaminated with salt, although the area is of a marshy nature. Clay suitable for the construction of dykes, however, was located on the site. Much of the surface is of a porous nature, creating problems in regard to the "seepage" of the brine. A plastics pipeline has been chosen to cope with the corrosive action of brine; it will be laid a considerable distance out into the sea. Once the area is "flooded" with brine, the liquid will be concentrated by solar evaporation and, as concentration proceeds, the salt and the mineral substances will be precipitated progressively in the pans of the "catchment" area. The carnallite will be harvested and treated for recovery of the potash. It is expected that the operation of the pilot plant will commence in about nine months' time. It is estimated that the whole project, when implemented, will involve an expenditure of about £4,500,000 sterling.

VEHICLE LIGHTING REGULATIONS.—It will be recalled that the periodic testing scheme for road vehicles of the Ministry of Transport and Civil Aviation is envisaged as examining for compliance with Construction and Use Regulations. In order to allow the examination to cover vehicle lighting equipments and reflectors, it is proposed to amend the law to require motor vehicles to be fitted at all times with front and rear lamps and reflectors to satisfy the Road Transport Lighting Acts, and to comply with the anti-dazzle lighting regulation. Exemption will be given during daylight for instances where a defect arises during a journey, or a vehicle not intended for use at night. It is claimed that "Representative organisations, departments, &c., are now being consulted on these proposals."

AIRCRAFT PRODUCTION CONFERENCE.—The seventh Annual Conference on the Problems of Aircraft Production, promoted by the Southampton section of the Institution of Production Engineers, will take place on Thursday and Friday, April 16–17, 1959; the conference theme will be "The Aircraft Industry—A National Asset." The Lord Sempill paper will be presented by Lord Douglas of Kirtleside, G.C.B., M.C., D.F.C., under the title "The Operator." The final session will be an open forum at which Lord Douglas and others, including Sir Arnold Hall, F.R.S., M.A., A.C.G.I., F.R.Ae.S., will discuss the importance of the aircraft industry in the national economy. The conference fee will be £4: applications should be sent to the secretary of the Institution of Production Engineers, 10, Chesterfield Street, London, W.1.

INDUSTRIAL FILMS.—Two new colour films, produced by the Mond Nickel Company, Ltd., were shown recently in London. Both are available on free loan. "Spheroidal Graphite Cast Iron" describes the advantages and limitations of ordinary cast iron and shows how, with the alteration of graphite shape, S.G. iron takes on some of the properties of steel while retaining its castability. Impact and twisting tests are shown, and graphs are included giving the stress strain curves for "Ferritic" and "Pearlitic" S.G. iron. The film runs for twenty-eight minutes. The second film, "Nickel Alloy Permanent Magnets," demonstrates the properties of nickel alloys for permanent magnets, with particular reference to their stability and strength. The film surveys some of the mechanical and electrical developments and applications which have been facilitated by these materials. The high stability of nickel-containing magnets is illustrated by subjecting an "Alcomax" magnet to extremes of heat, cold and vibrations. The film runs for twenty-one minutes.

CO_2/SILICATE MOULDING PROCESS.—We are informed by Imperial Chemical Industries, Ltd., that an agreement has been reached with the Czech patentees of the carbon dioxide/sodium silicate process for making foundry moulds and cores which promises to clear the way for further development of this process in Britain. The announcement points out that the process has already been fairly widely accepted into foundry practice in the United Kingdom but uncertainties surrounding the future of British Patent No. 654,817, may have hampered its full development in this country. This patent lapsed in 1953, and an application made in 1954 by the patentees (Vitkovicke Zelezarny Klementa Gottwalda and Dr.-Ing. Lev Petrzela, of Czechoslovakia) for its restoration is at present before the British Patent Office. By an agreement with V.Z.K.G. and Dr. Petrzela, I.C.I., Ltd., has secured an exclusive licence under the patent, if restored, with the right to grant sub-licences, and these will be offered to the foundry trade free from royalty. Independently of the restoration of the patent, I.C.I., Ltd., states that it has secured full access to all the technical information at present in the possession of V.Z.K.G. and Dr. Petrzela, and any that becomes available from their continuing research work on the process in Czechoslovakia. This agreement promises to release much valuable information to the foundry trade in this country.

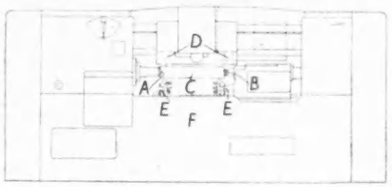
British Patent Specifications

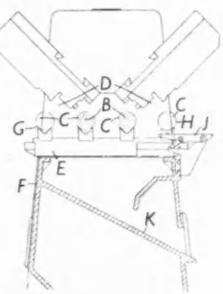
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.

MACHINE TOOLS

803,434. October 25, 1955.—MACHINE TOOLS, Douglas Fraser and Sons, Ltd., Westburn Foundry, Arbroath, Angus, Scotland. (*Inventors: Norman Fraser and Herbert Geoffrey Bottomley.*)

The invention relates to an improved machine tool, particularly a lathe. In a machine tool according to the invention, the tool holder is so mounted directly above the common axis of the centres that an uninterrupted path substantially normal or inclined to a vertical plane containing the axis of the centres is presented beneath the holder. This provides an uninterrupted passage of the work from a loading station at one side to an unloading station at the opposite side to facilitate automatic loading and unloading. Four embodiments of machine tool are dealt with in the specification. Referring to the drawing, the machine tool includes two pairs of transversely spaced coaxial centres *A* and *B* adapted in turn to support the work *C*. The axes of the two pairs of centres are parallel and in the same horizontal plane to provide for successive operations on the work—for example, roughing and finishing cuts. *D* is one of two tool holders each being associated with a pair of centres *A* and *B* and located directly above the common axis of centres *B* for movement in a predetermined path or paths relatively to the work *C*. The tool holders are inclined in opposite directions towards the associated pairs of centres. *E* denotes a horizontal reciprocatory conveyor extending transversely of the machine tool between the tool holder *D* and the bed *F* and adapted to travel with an interrupted motion to convey the work *C* from a loading station *G* at one side of the machine into working positions between the centres of each pair in turn and to an unloading station *H* at the opposite side. At the station *H* an ejector device *J* is provided to support and to lift the work clear of the conveyor. The bed *F* is formed under the conveyor *E* with a chute *K* to receive swarf. —*October* 22, 1958.



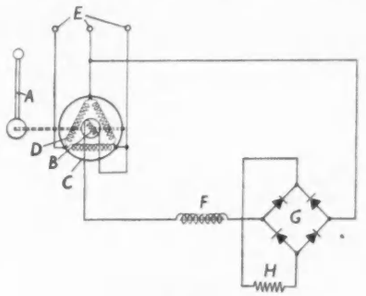


No. 803,434

ELECTRICAL ENGINEERING

803,224. August 16, 1955.—CONTROL SYSTEMS FOR ELECTRIC MOTORS, The General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2. (*Inventor: Erich Siegfried Friedlander.*)

The invention relates to electric motor control systems of the speed signalling type, in which a reference signal derived from a controller is fed into a control circuit of the motor for controlling speed. One object of the present invention is for controlling the winder motor of an electric winding equipment. The drawing shows a circuit diagram of the manual control system. Referring to the drawing, in manual control systems of the speed signalling type for winder motors, it is usual for the speed of the winder motor to be dependent upon the position of a driver's hand lever, which, as will be described, selects a signal voltage for controlling the speed of the motor. Mechanically connected to the hand lever *A* is the rotor *B* of a three-phase induction regulator *C*. The stator *D* of the induction regulator is connected across a three-phase supply *E* and its rotor *B* is connected across two lines of the supply through a saturable reactor *F* and full-wave rectifier *G* and in opposition to one line-to-line stator voltage. With this arrangement it is possible to have zero output voltage for a given angular position of the rotor *B*, and a substantially linear rise for angular displacements in either direction from the zero output voltage position. The actual change of voltage is sinusoidal but, as will be appreciated, it is only the substantially linear part of the change that is used. For low and minimum speeds of the winder motor it is essential to have great precision of control to provide manœuvrability for decking and it is therefore necessary to have large movements of the hand lever *A*, that is large displacements of the rotor *B*, for small changes in speed of the winding motor. One method of providing this precision of control in accordance with the present invention is to place the saturable reactor *F* in the output circuit of the induction regulator *C* and in series with the full-wave rectifier *F*, the d.c. pattern signal voltage for feeding into the speed control circuit of the winder motor being the voltage developed across a resistance *H* connected to the output terminals of the rectifier *G*. The saturable reactor *F* makes it possible to introduce just the type of nonlinearity wanted to obtain a voltage signal which varies only little with an appreciable movement of the control lever *A* for the purpose of easy manœuvring at minimum speed and then by relatively quick transition into another range in which further movement of the control lever *A* produces a very much greater variation of voltage signal with movement of the hand lever.—*October* 22, 1958.

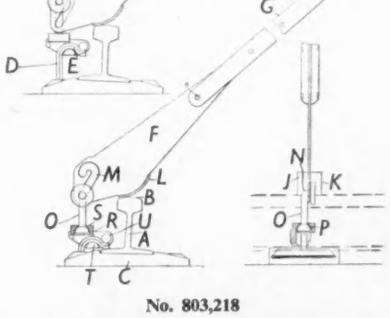


No. 803,224

RAILWAY ENGINEERING

803,218. August 25, 1954.—RAIL SPIKE EXTRACTORS, G. D. Peters and Co., Ltd., Windsor Works, Slough. (*Inventor: Cyril Ernest Gayes.*)

The invention relates to rail spike extractors and has more especial reference to hand-operated portable units intended for the extraction of elastic rail spikes of the type now commonly employed for securing flat bottomed rails to their base plates and sleepers or foundations. Referring to the drawing, *A* is a flat-bottomed rail having a tread *B* and resting on a base plate or chair *C*, to which it is secured by a rail spike *D* having a conventionally hooked portion *E* which engages over the flat-bottomed web of the rail. *F* is the extractor lever which is of flat bar section and has an operating handle *G* of wood. A heel is formed on the lower edge of the bar *F* by a pair of lateral projections *J* and *K*, these being spaced from the toe of the lever by approximately the distance which separates the rail spike *D* from the rail *A*, and being curved at *L*, so as to provide a smooth rolling fulcrum when the tool is located on the rail head during the extraction of the spike. In the toe of the lever *F* is a slot *M* in which rides a transverse pivot *N* constituted by a bell cranked portion of a swing link *O* at the bottom of which is a part spherical projection *P*, providing a bearing for a swivelling foot generally designated *R*. The swivelling foot *R* has a cup-shaped recess *S*, bearing on the portion *P* of the link, and two lateral projections *T* and *U*, the first adapted to engage under the hook *E* of the rail spike, and the other *U* over the tip of the hook so as to prevent springing when the spike is being extracted. As is clearly illustrated the projection or lug *T* is of semi-cylindrical section readily to pass under the hook of a spike in operative position, while the second projection or lug *U* is a cylindrical pin, both elements projecting laterally from a depending side arm on the forging *R*, which can rock as well as swivel about the axis of the link *O*. The link *O* may be hung from two different positions, one with the pivot *N* at the lower end of the S-shaped slot *M* as in the centre view, and the other with the pivot *N* at the upper end of the slot *M* as in the upper view, the latter being of particular use when a spike *D* has been partially withdrawn as in this figure.—*October* 22, 1958.

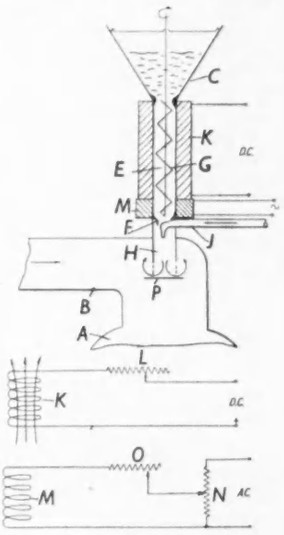


No. 803,218

THE CLEANING OF GASES

803,177. July 6, 1956.—THE REMOVAL OF FUME FROM GASES, The British Oxygen Company, Ltd., Bridgewater House, Cleveland Row, St. James's, London, S.W.1. (*Inventor: Jozef Kazimierz Tylko.*)

It is an object of the invention to provide an efficient method of agglomerating fumes consisting predominantly of ferro-magnetic material of fine particle size prior to their removal from the suspending gas by conventional fume removal equipment, such as cyclones, settlers, and the like. Referring to the drawing, the apparatus comprises an agglomerating chamber *A* having an inlet pipe *B* for fume-laden gas at the top. On the inlet pipe *B* is mounted the magnetised powder dispensing assembly which comprises a funnel-shaped hopper *C* for the powder *D*, from which the powder is discharged through a long cylindrical conduit *E* terminating in a nozzle *F* by means of a feeding device, shown as a screw *G*. From the nozzle the powder passes into an open-ended mixing chamber *H* located within the pipe *B*. A stream of a compressed carrier gas is introduced into the mixing chamber through a separate nozzle *J*, placed so that the jet of gas leaving the nozzle will entrain powder entering the mixing chamber *H* through the nozzle *F*. During its passage through the conduit *E*, the powder is given a controlled amount of residual magnetism by passage through a magnetic field produced by direct current flowing through a coil *K*. The coil *K* is connected to the d.c. supply through a variable resistance *L*, which permits adjustments in the magnetising current. In order to prevent too high a residual magnetism and to ensure a uniform intensity of magnetisation in the powder, a demagnetising coil *M* surrounds the conduit below the coil *K*. An alternating current is fed to this coil, the value of the current being adjustable from a maximum to zero by means of a variable high resistance *N*, acting as a potential divider, and a variable low resistance *O*, acting as a fine adjustment control. This control of residual magnetism of the powder secures even dispersion in the nozzle *F*. The magnetised powder suspended in the carrier gas passes from the mixing chamber past a baffle *P* into the pipe *B*, where it mixes with the stream of fume-containing gas and the mixture passes into the agglomerating chamber *A*, where agglomeration of the fume and powder takes place. The agglomeration chamber is connected to conventional fume-removal apparatus, in which the agglomerated particles are removed from the gas. The magnetised and precipitated particles derived from the fume may be reintroduced into the hopper *C* and re-used.—*October* 22, 1958.



No. 803,177

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, Nov. 28.—SOUTH EAST LONDON BRANCH : Visit to Courage and Barclay's Brewery, London, 6.30 p.m. ★ STOKE AND CREWE BRANCH : Grand Hotel, Hanley, "Power Factor Correction," F. T. Bartho, 7.30 p.m.

Mon., Dec. 1.—BOLTON BRANCH : Railway Hotel, Trinity Street, Bolton, "Infra-Red Heating," 7.45 p.m. ★ LEEDS BRANCH : Great Northern Hotel, Leeds, "Modern Cable-Making Methods," 7.30 p.m. ★ LONDON NATIONAL LECTURE : Institution of Electrical Engineers, Savoy Place, London, W.C.2, Discussion on "Education, Training and Status of Electrical Technicians," 6.30 p.m. ★ NORTH-EAST LONDON BRANCH : Angel Hotel, Ilford, "Affairs of the Association," J. H. K. Pendry, 8 p.m.

Tues., Dec. 2.—WEST LONDON BRANCH : Windsor Castle Hotel, 134, King Street, Hammersmith, London, W.6, "Progress in Electronic Switching in Telephone Exchanges," N. C. Smart, 7.30 p.m.

Wed., Dec. 3.—HALIFAX BRANCH : Crown Hotel, Horton Street, Halifax, "Traffic Control and Road Safety," Inspector Watson, 7.45 p.m. ★ NORTH LONDON BRANCH : Wood Green Town Hall, Wood Green, London, N.22, "Electrical Water Treatment," A. G. Freeborn, 7.45 p.m. ★ NOTTINGHAM BRANCH : Mechanics' Institution, Trinity Square, Nottingham, "Switchgear Testing," B. Jones, 7.30 p.m. ★ PRESTON BRANCH : R.A.F.A. Club, East View, Preston, "Electrical Association for Women," Mrs. H. E. Rhodes, 7.30 p.m.

Thurs., Dec. 4.—SOUTHAMPTON BRANCH : Pilgrim Room, Polygon Hotel, Southampton, Joint Lecture with the Electrical Association for Women, 8 p.m.

Fri., Dec. 5.—BRISTOL AND WEST OF ENGLAND BRANCH : Grand Hotel, Bristol, "Capacitors Pay Dividends," 8 p.m. ★ LIVERPOOL AND DISTRICT BRANCH : Industrial Development Centre, M.A.N.W.E.B., Paradise Street, Liverpool, 1, "Flameproof Installations," W. T. Partington, 7.30 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

To-day, Nov. 28.—SOUTH MIDLANDS SECTION : North Gloucestershire Technical College, Cheltenham, "Television Recording," P. J. Guy, 7 p.m. ★ MERSEYSIDE SECTION : University Club, Liverpool, "The First Transatlantic Telephone Cable," F. Scowen, 7 p.m.

Thurs., Dec. 4.—NORTH WESTERN SECTION : Reynolds Hall, College of Technology, Sackville Street, Manchester, 1, "High Input Impedance D.C. Amplifiers," S. Stuart, 6.30 p.m.

CENTRAL LONDON PRODUCTIVITY ASSOCIATION

Thurs., Dec. 4.—Council Chamber, Federation of British Industries, 21, Tothill Street, London, S.W.1, "An Educational Policy and Programme for a Small Firm," 2.30 p.m.

COMBUSTION ENGINEERING ASSOCIATION

Thurs., Dec. 4.—NORTHERN REGION : Hotel Metropole, Leeds, Brains Trust on "The Utilisation of Low Grade Fuels," 2.30 p.m.

ILLUMINATING ENGINEERING SOCIETY

To-day, Nov. 28.—BIRMINGHAM CENTRE : Regent House, St. Philip's Place, Colmore Row, Birmingham, "Headlamps and Signals for Motor Cars," J. H. Nelson, 6 p.m.

Mon., Dec. 1.—LEEDS CENTRE : Yorkshire Electricity Board, Ferensway, Hull, "Photo-Electric Cells and their Applications," F. A. Benson, 6.30 p.m.

Tues., Dec. 2.—STOKE-ON-TRENT GROUP : North Stafford Hotel, Stoke-on-Trent, Brains Trust, 6 p.m.

Wed., Dec. 3.—EDINBURGH CENTRE : Y.M.C.A., 14, South St. Andrew Street, Edinburgh, "Glassware for Lighting Fittings," D. Shellshear and C. D. Cartwright, 6.30 p.m. ★ SWANSEA GROUP : Demonstration Theatre, South Wales Electricity Board, The Kingsway, Swansea, "Industrial Lighting Problems," W. Imrie-Smith, 6.30 p.m.

Thurs., Dec. 4.—CARDIFF CENTRE : Demonstration Theatre, South Wales Electricity Board, The Hayes, Cardiff, "Industrial Lighting Problems," W. Imrie-Smith, 6 p.m. ★ GLASGOW CENTRE : British Lighting Council, 29, St. Vincent Place, Glasgow, C.1, "Glassware for Lighting Fittings," D. Shellshear and C. D. Cartwright, 6.30 p.m. ★ MANCHESTER CENTRE : North Western Electricity Board, Town Hall Extension, Manchester, 2, "Recent Developments in Lighting Design Techniques," H. E. Bellchambers, 6 p.m. ★ NOTTINGHAM CENTRE : Electricity Service Centre, Nottingham, "Lighting —and Other Things—in Moscow and Leningrad," A. G. Penny, 6 p.m.

INCORPORATED PLANT ENGINEERS

To-day, Nov. 28.—BIRMINGHAM BRANCH : Imperial Hotel, Temple Street, Birmingham, "Statutory Regulations of Steam and Pressure Vessels," 7.30 p.m.

Tues., Dec. 2.—LONDON BRANCH : Royal Society of Arts, John Adam Street, Adelphi, Strand, London, W.C.2, "The Historical Development of Electric Traction," E. Openshaw Taylor, 7 p.m. ★ PETERBOROUGH BRANCH : White Lion Hotel, Church Street, Peterborough, "Road Construction," J. M. Fisher, 7.30 p.m.

Wed., Dec. 3.—EAST MIDLANDS BRANCH : Sherwood Room, County Hotel, Theatre Square, Nottingham, Ladies' Film Evening, 7 p.m. ★ LEICESTER BRANCH : Bell Hotel, Leicester, Ladies' Film Evening, 7 p.m. ★ SOUTHERN BRANCH : Royal Beach Hotel, Southsea, "Safety in the Use of Electricity," S. J. Emerson, 7.30 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Thurs., Dec. 4.—LONDON BRANCH : 17, Belgrave Square, London, S.W.1, Joint Meeting with the Institute of Metals, "Continuous Casting of Bronze," E. C. Ellwood, 6.30 p.m.

INSTITUTE OF MARINE ENGINEERS

To-day, Nov. 28.—SOUTH WALES SECTION : Technical College, Swansea, "The Duties in the Day of a Seagoing Engineer," T. C. Bishop, 2 p.m.

Mon., Dec. 1.—STUDENT LECTURE : Memorial Building, 76, Mark Lane, London, E.C.3, "Modern Marine Watertube Boilers," A. P. Monk, 6.30 p.m.

Thurs., Dec. 4.—KINGSTON-UPON-HULL AND EAST MIDLANDS SECTION : Royal Station Hotel, Kingston-upon-Hull, "Marine Machinery Breakdowns," J. H. Milton, 7.30 p.m.

INSTITUTE OF PETROLEUM

Wed., Dec. 3.—LONDON BRANCH : 61, New Cavendish Street, London, W.1, "Flow Properties of Distillates at Low Temperatures : A Review," J. F. Hutton ; "Pumpability of Aviation Turbine Fuels at Low Temperatures," H. Strawson, 5.30 p.m.

INSTITUTE OF REFRIGERATION

Thurs., Dec. 4.—Institute of Marine Engineers, Memorial Building, 76, Mark Lane, London, E.C.3, "A Review of the Moscow Meetings of the International Institute of Refrigeration," 5.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Tues., Dec. 2.—EASTERN CENTRE : Golden Hind Hotel, Cambridge, "Costs and Costing Relating to the Operation and Maintenance of a Fleet of Vehicles," W. J. Edbrooke, 7 p.m.

Wed., Dec. 3.—EAST MIDLANDS CENTRE : Mechanics' Institute, Nottingham, "Petrol Injection," J. N. Morris, 7.30 p.m.

INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS

Fri., Dec. 5.—LONDON BRANCH : 6, Buckingham Gate, London, S.W.1, "How Far are British Tillage and Harvesting Machines Meeting Overseas Conditions," 2.15 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Tues., Dec. 2.—NORTH WESTERN BRANCH : Chemical Engineering Building, Manchester College of Science and Technology, Jackson Street, Manchester, "Wetted Area in Packed Towers," W. S. Norman and B. Solomon, 6.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Dec. 2.—Great George Street, Westminster, London, S.W.1, "Shoreham Harbour Development," H. Ridehalgh, 5.30 p.m.

Thurs., Dec. 4.—NORTH WESTERN ASSOCIATION : Engineers' Club, 17, Albert Square, Manchester, "Recent Developments in Soil Mechanics as Applied to Road Construction," S. Raymond, 6,30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

To-day, Nov. 28.—SOUTHERN CENTRE : South Dorset Technical College, Weymouth, "The Design of Transistors," J. R. Tillman, 6.30 p.m.

Mon., Dec. 1.—NORTH-EASTERN RADIO AND MEASUREMENT GROUP : King's College, Newcastle upon TYNE, "An Experimental Approach to the Cooling of Transformer Coils by Natural Convection," E. D. Taylor, B. Berger and B. E. Western, 6.15 p.m. ★ SOUTH MIDLAND CENTRE : College of Technology, Gosta Green, Birmingham, "Standardization of Control Facilities for the British Grid : Communications, Indications, and Telemetering," P. F. Gunning, "The Development of Communication, Indication and Telemetering Equipment for the British Grid," G. A. Burns, F. Fletcher, C. H. Chambers and P. F. Gunning, 6 p.m. ★ MAIDSTONE BRANCH : Medway College of Technology, Chatham, "The Organisation for Large-Scale Grid System Tests," F. H. Last, E. Mills and N. D. Norris, 7 p.m.

Tues., Dec. 2.—MEASUREMENT AND SUPPLY SECTIONS : Savoy Place, London, W.C.2, "Power-System Automatic Frequency Control Techniques," F. Moran, 5.30 p.m. ★ NORTH MIDLAND CENTRE : C.E.G.B. Offices, Leeds, "Operational Experience at Calder Hall," K. L. Stretch, 6.30 p.m. ★ NORTH-WESTERN CENTRE : Engineers' Club, 17, Albert Square, Manchester, "Thermonuclear Fusion and the Development of 'ZETA,'" E. R. Hartill, 6.15 p.m. ★ SOUTH EAST SCOTLAND SUB-CENTRE : Carlton Hotel, North Bridge, Edinburgh, "The Generation of Electricity in the London Area," H. V. Pugh, 7 p.m. ★ SOUTH MIDLAND CENTRE : Town Hall, Birmingham, "Automation," H. A. Thomas, 7 p.m.

Wed., Dec. 3.—LONDON GRADUATE AND STUDENT SECTION : Medway College of Technology, Chatham, Kent, Film Evening, 7 p.m. ★ SOUTHERN CENTRE : S.E.E.B. Offices, 10, Queen Gardens, Hove, "The Television Studio as Seen by the Producer," A. Rakoff, 6.30 p.m. ★ TEES-SIDE SUB-CENTRE : Cleveland Scientific and Technical Institute, Corporation Road, Middlesbrough, "Colour Television," C. J. Stubbington, 6.30 p.m.

Thurs., Dec. 4.—ORDINARY MEETING : Savoy Place, London, W.C.2, "A Review of Work Towards Nuclear Energy from Controlled Thermonuclear Reaction," D. W. Fry, 5.30 p.m. ★ EAST MIDLAND CENTRE : De Montfort Hall, Leicester, "Automation," H. A. Thomas, 7.15 p.m. ★ NORTH MIDLAND CENTRE : Yorkshire Electricity Board Offices, Ferensway, Hull, "Organization for Large-Scale Grid System Tests," F. N. Last, E. Mills and N. D. Norris, 6.30 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., Dec. 2.—39, Elmbank Crescent, Glasgow, "Alignment of Shafting," 6.30 p.m.

INSTITUTION OF HIGHWAY ENGINEERS

Wed., Dec. 3.—EAST ANGLIA BRANCH : Assembly House, Theatre Street, Norwich, "Roads from the Beginning," E. J. R. Kennersell, 6.45 p.m.

Fri., Dec. 5.—LONDON BRANCH : Institution of Structural Engineers, 11, Upper Belgrave Street, London, S.W.1, "Motorway Design and Construction in Worcestershire," W. R. Thomson, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Nov. 28.—LONDON BRANCH : 1, Birdcage Walk, Westminster, London, S.W.1, Technical Film Show, 6 p.m. ★ NORTH EASTERN GRADUATES' SECTION : King's College, Newcastle upon Tyne, Debate, "The Benefits of Nuclear Energy are Outweighed by its Disadvantages," 6.30 p.m.

Mon., Dec. 1.—NORTH EASTERN BRANCH : Neville Hall, Westgate Road, Newcastle upon Tyne, "Management Control of Small Engineering Firms," L. Fontaine, W. R. Spencer and J. W. Walker, 6 p.m. ★ EASTERN GRADUATES' SECTION : Technical College, Collier Road, Cambridge, "Something for Nothing ? Heat Pump Achievement," G. O. McLean, 6.30 p.m.

Tues., Dec. 2.—EDUCATION GROUP : 1, Birdcage Walk, Westminster, London, S.W.1, Discussion on "The Planning of Mechanical Engineering Teaching Laboratories," 6 p.m. ★ NORTH EASTERN BRANCH: Cleveland Scientific and Technical Institute, Corporation Road, Middlesbrough, "Management Control of Small Engineering Firms," L. Fontaine, W. R. Spencer and J. W. Walker, 6.15 p.m. ★ COVENTRY A.D. CENTRE : Grosvenor Room, Leofric Hotel, Coventry, Symposium on "Petrol Injection," E. W. Downing, 7.15 p.m. ★ NORTH WESTERN A.D. CENTRE : Engineers' Club, Manchester, "Inspection of Vehicles for Road Worthiness, with Special Reference to Methods and Equipment," G. Grime, and R. D. Lister, 7.15 p.m.

Wed., Dec. 3.—EAST MIDLANDS GRADUATES' SECTION : College of Further Education, Greenclose Lane, Loughborough, "Air Compressors for the 8ft by 8ft High-Speed Wind Tunnel at the R.A.E., Bedford," L. J. Cheshire, J. Y. G. Evans, W. A. Goodsell and P. H. W. Wolff, 7.15 p.m.

Thurs., Dec. 4.—NORTH WESTERN BRANCH : Engineers' Club, Albert Square, Manchester, "Design and Construction of the Main Compressor for the 8ft by 8ft High-Speed Wind Tunnel at the R.A.E., Bedford," L. J. Cheshire, J. Y. G. Evans, W. A. Goodsell and P. H. W. Wolff, 6.45 p.m. ★ NORTHERN IRELAND GRADUATES' SECTION : Kerr Room, Kensington Hotel, Belfast, "Electro-Hydraulic Servomechanisms," E. G. Morley, 7.30 p.m. ★ YORKSHIRE GRADUATES' SECTION : Grand Hotel, Sheffield, "Public Clocks," W. A. Potts, 6.30 p.m.

Fri., Dec. 5.—ORDINARY MEETING : 1, Birdcage Walk, Westminster, London, S.W.1, "Experimental Investigation into the Stress Distribution in a Band Reinforced Pressure Vessel," K. G. Mantle, N. Marshall and P. J. Palmer, 6 p.m. ★ SCOTTISH SECTION : Robert Gordon's College, Aberdeen, "The Steam Catapult," C. C. Mitchell, 7.30 p.m.

INSTITUTION OF NAVAL ARCHITECTS

Thurs., Dec. 4.—Weir Lecture Hall, 10, Upper Belgrave Street, London, S.W.1, "The Design of Inflatable Liferafts," C. H. Latimer-Needham, 4.45 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

To-day, Nov. 28.—CARDIFF SECTION : South Wales Institute of Engineers, Park Place, Cardiff, "Tooling with Epoxy Resins," E. M. White, 7 p.m.

Tues., Dec. 2.—PETERBOROUGH SECTION : White Lion Hotel, Church Street, Peterborough, "Road Construction," 7.30 p.m. ★ NEWCASTLE UPON TYNE GRADUATE SECTION : Visit to Caterpillar Tractor Company, Ltd., Birtley, 6.15 p.m.

Wed., Dec. 3.—HALIFAX AND HUDDERSFIELD SECTION : Technical College, Huddersfield, "Management of the Small Firm," E. W. Etchells, 7.30 p.m. ★ NOTTINGHAM SECTION : Reform Club, Victoria Street, Nottingham, "Production Control," 7 p.m. ★ WESTERN SECTION : Small Lecture Theatre, The University, Bristol, "Material Handling—A Challenge to British Industry," A. G. Hayek, 7.30 p.m.

Thurs., Dec. 4.—LONDON SECTION : Powers Samas Accounting Machines, Ltd., Aurelia Road, Croydon, Surrey, "Punched Cards and Automation," D. F. Nettell, 7 p.m. ★ READING SECTION : Great Western Hotel, Reading, "The Value of the Consultant to Industry," A. F. Masters, 7.30 p.m.

INSTITUTION OF THE RUBBER INDUSTRY

Mon., Dec. 1.—NORTH EASTERN SECTION : Eldon Grill, Grey Street, Newcastle, Textile Research Paper by R. S. Goy, 7 p.m. ★ PRESTON SECTION : Bull and Royal Hotel, Church Street, Preston, "Productivity and Industrial Relations," S. W. Reid, 7.15 p.m.

Wed., Dec. 3.—BURTON-ON-TRENT SECTION : Midland Hotel, Station Street, Burton-on-Trent, "New Developments in Rubber," S. C. Stokes, 7.30 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

To-day, Nov. 28.—MIDLAND COUNTIES BRANCH : James Watt Memorial Institute, Birmingham, "International Union of Architects, 1958 Congress in Moscow," A. G. Ling, 6.30 p.m.

Mon., Dec. 1.—LONDON GRADUATES' AND STUDENTS' SECTION : 11, Upper Belgrave Street, London, S.W.1, Films, 6.30 p.m.

Tues., Dec. 2.—NORTHERN COUNTIES BRANCH : Cleveland Scientific and Technical Institution, Middlesbrough, "Concrete Roads—Some Recent Developments," D. R. Sharp, 6.30 p.m. ★ NORTHERN IRELAND BRANCH : College of Technology, Belfast, "Report on the Third International Congress on Prestressing, Berlin, May, 1958," J. McClure, 6.45 p.m.

Wed., Dec. 3.—YORKSHIRE BRANCH : Royal Victoria Hotel, Sheffield, "Precast Concrete Structures with Particular Reference to Folded Slab Roof Construction," F. J. Samuely, 6.30 p.m. ★ LANCASHIRE AND CHESHIRE BRANCH : College of Science and Technology, Manchester, "Points of Structural Interest at Calder Hall," W. S. Watts, 6.30 p.m. ★ NORTHERN COUNTIES BRANCH : Neville Hall, Newcastle upon Tyne, "Concrete Roads—Some Recent Developments," D. R. Sharp, 6.30 p.m.

Fri., Dec. 5.—MIDLAND COUNTIES BRANCH GRADUATES' AND STUDENTS' SECTION : Birmingham Exchange and Engineering Centre, Birmingham, "The Jodrell Bank Radio Telescope," 6.30 p.m. ★ WESTERN COUNTIES BRANCH : University Engineering Laboratories, Bristol, "Modular Planning in the Drawing Office," G. R. Caines, and "The Measurement of Strain by an Electrical Method," J. R. Daniell, 6 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Nov. 28.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, Annual General Meeting, 7 p.m.

Wed., Dec. 3.—MIDLAND SECTION : James Watt Memorial Institute, Great Charles Street, Birmingham, "Factory Heating and Ventilating," J. F. Elsworth, 7 p.m.

Fri., Dec. 5.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, Films, 7 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

To-day, Nov. 28.—College of Science and Technology, Manchester, "Electro-Mechanical Themes in Machine Tool Design," The Rt. Hon. the Earl of Halsbury, 7.30 p.m.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

To-day, Nov. 28.—Lecture Theatre, Mining Institute, Neville Hall, Newcastle upon Tyne, "Tests on Light Alloy Stiffener Sections," M. N. Parker, 6.15 p.m.

REINFORCED CONCRETE ASSOCIATION

Mon., Dec. 1.—N.W. BRANCH : College of Technology, Sackville Street, Manchester, "Precast Concrete in Framed Buildings," E. S. Benson, 6.45 p.m.

Tues., Dec. 2.—N.W. BRANCH : Liverpool Engineering Society, The Temple, 24, Dale Street, Liverpool, "Precast Concrete in Framed Buildings," E. S. Benson, 6.30 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Mon., Dec. 1.—12, Great George Street, Westminster, London, S.W.1, "A Chartered Surveyor Looks at Soviet Russia," H. W. Wells, 5.45 p.m.

Fri., Dec. 5.—12, Great George Street, Westminster, London, S.W.1, "Training the Metalliferous Mine Surveyor," J. S. Sheppard, 5.45 p.m.

ROYAL SOCIETY OF ARTS

Wed., Dec. 3.—John Adam Street, Adelphi, London, W.C.2, "The Consulting Engineer and His Contribution to the National Economy," Julian S. Tritton, 2.30 p.m.

ROYAL SOCIETY OF HEALTH

Thurs., Dec. 4.—Wulfrun Hall, Wolverhampton, Papers on "Radiation Hazards and the Local Authority," 10 a.m.

SOCIETY OF CHEMICAL INDUSTRY

Tues., Dec. 2.—CORROSION GROUP : 14, Belgrave Square, London, S.W.1, A Discussion of Three Research Papers, 6.30 p.m.

Thurs., Dec. 4.—CHEMICAL ENGINEERING GROUP : University of Bristol, Woodland Road, Bristol, "Titanium and its Alloys as Materials of Construction for Chemical Plant," K. W. J. Bowen, 6 p.m.

SOCIETY OF ENGINEERS

Mon., Dec. 1.—Geological Society, Burlington House, Piccadilly, London, W.1, "Some Industrial Applications of Magnetic Power," T. J. Hawker, 5.30 p.m.

SOCIETE DES INGENIEURS CIVILS DE FRANCE

Thurs., Dec. 4.—BRITISH SECTION : Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1. "The Design and Construction of the Shell Roof of the Exhibition Palace of the National Centre of Industries and Technology, Paris," M. Nicolas Esquillan, 6 p.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

To-day, Nov. 28.—SCOTTISH SECTION : Scottish Building Centre, 425, Sauchiehall Street, Glasgow, "Analytical Instrumentation of Chemical Processes," J. D. Tallantire, 7.15 p.m.

Tues., Dec. 2.—CHELTENHAM SECTION : Rotunda, Cheltenham, "The Industrial Uses of Computers," R. H. Tizard, 7.30 p.m.

TELEVISION SOCIETY

Thurs., Dec. 4.—Cinematograph Exhibitors' Association, 164, Shaftesbury Avenue, London, W.C.2, "A New Development in Flying Spot Film Scanners," E. H. Traub, 7 p.m.

WOMEN'S ENGINEERING SOCIETY

Thurs., Dec. 4.—LONDON BRANCH : Hope House, 45, Great Peter Street, Westminster, London, S.W.1, "Helicopters," 7 p.m.

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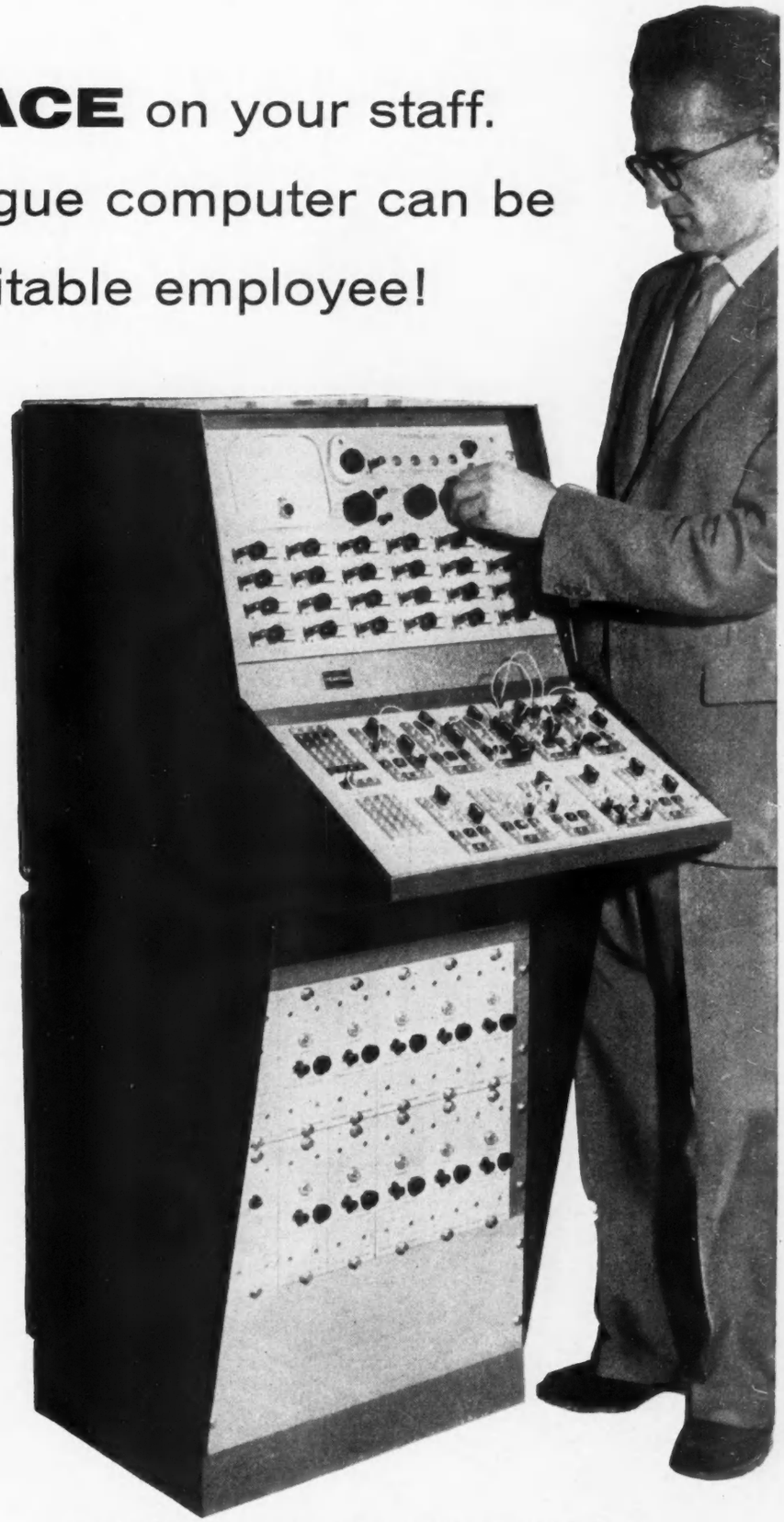

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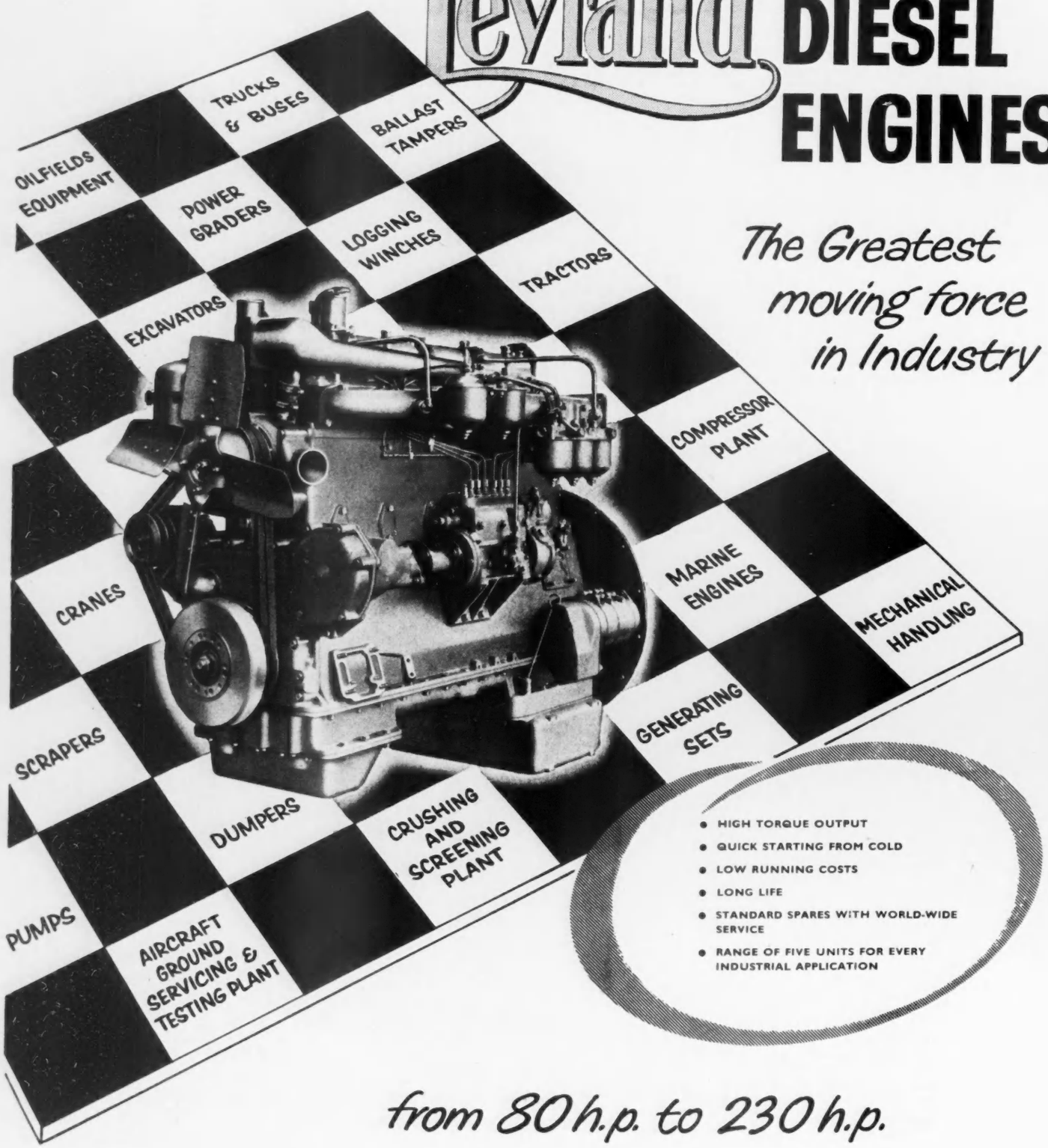

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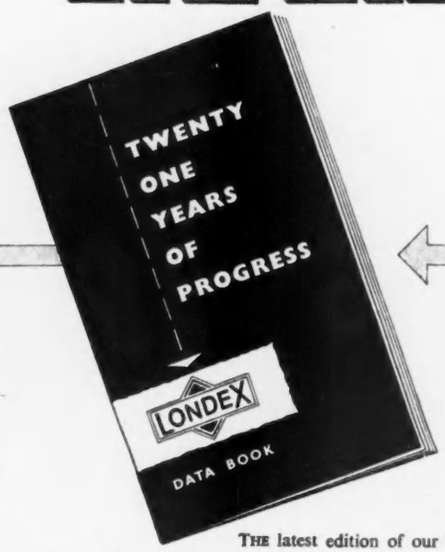

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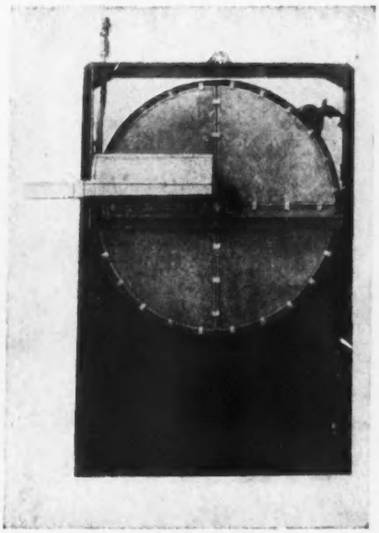

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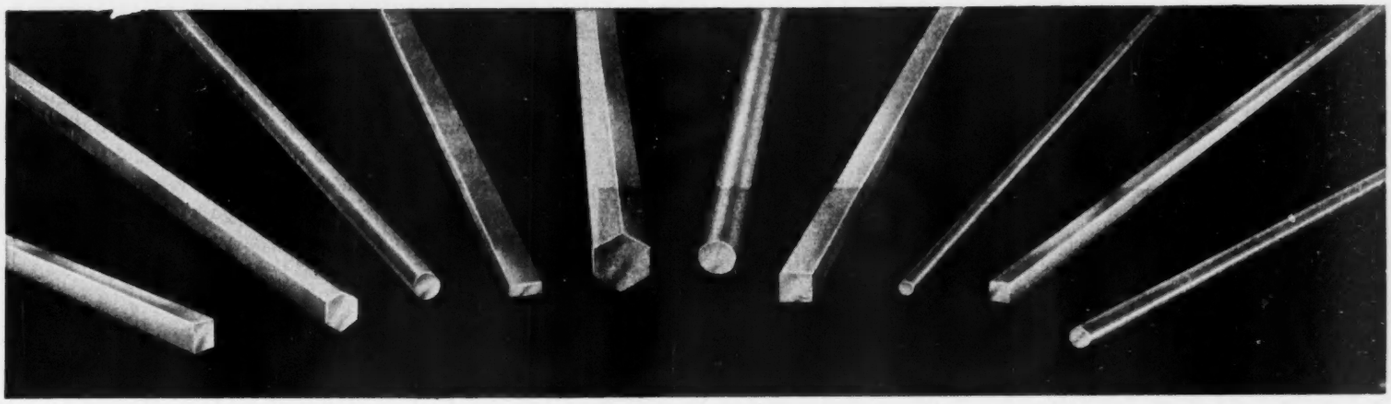

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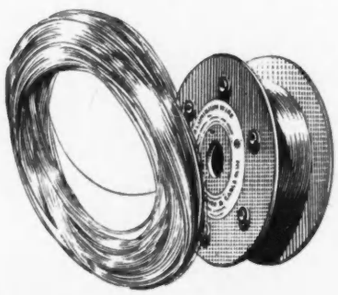

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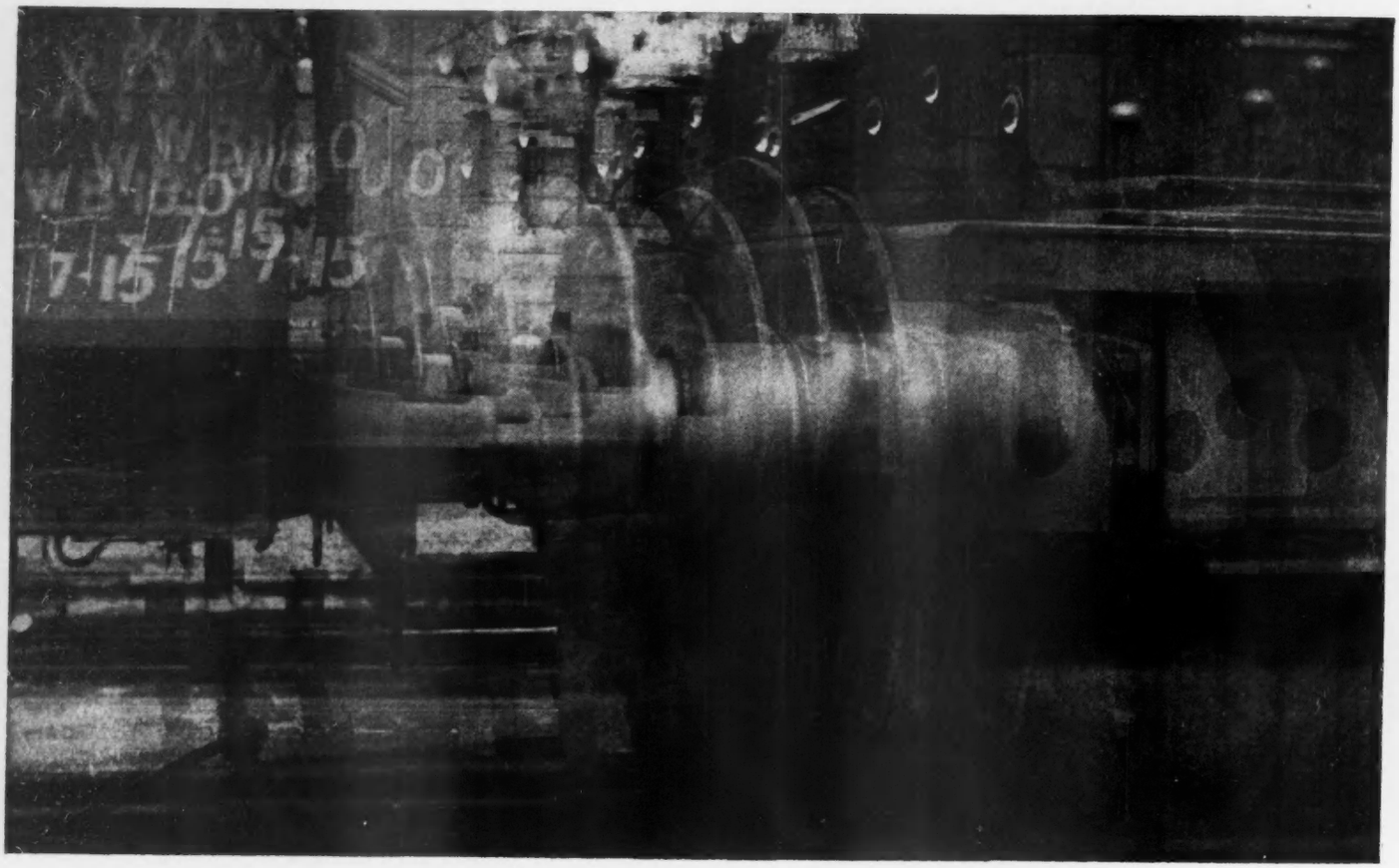

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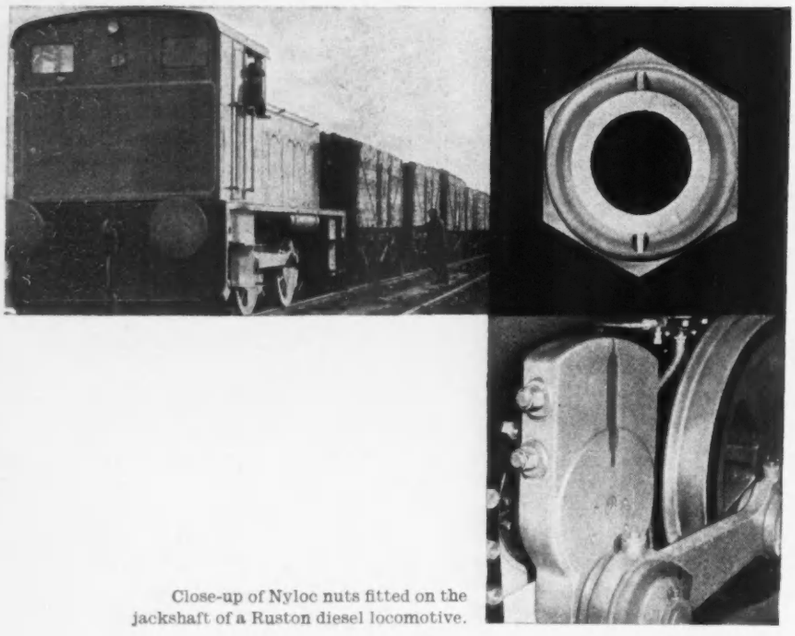

Close-up of Nyloc nuts fitted on the jackshaft of a Ruston diesel locomotive.

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● **BOOSTS HEAT OUTPUT . . .** Whatever type of oil-burning equipment is used the addition of FLAME-RITE to the fuel improves flame efficiency. A surface tension agent ensures complete and even atomization of all fuel passing through the burner, exposing the maximum surface area of fuel to the air supply, and so ensuring the hottest possible flame from any given amount of fuel.

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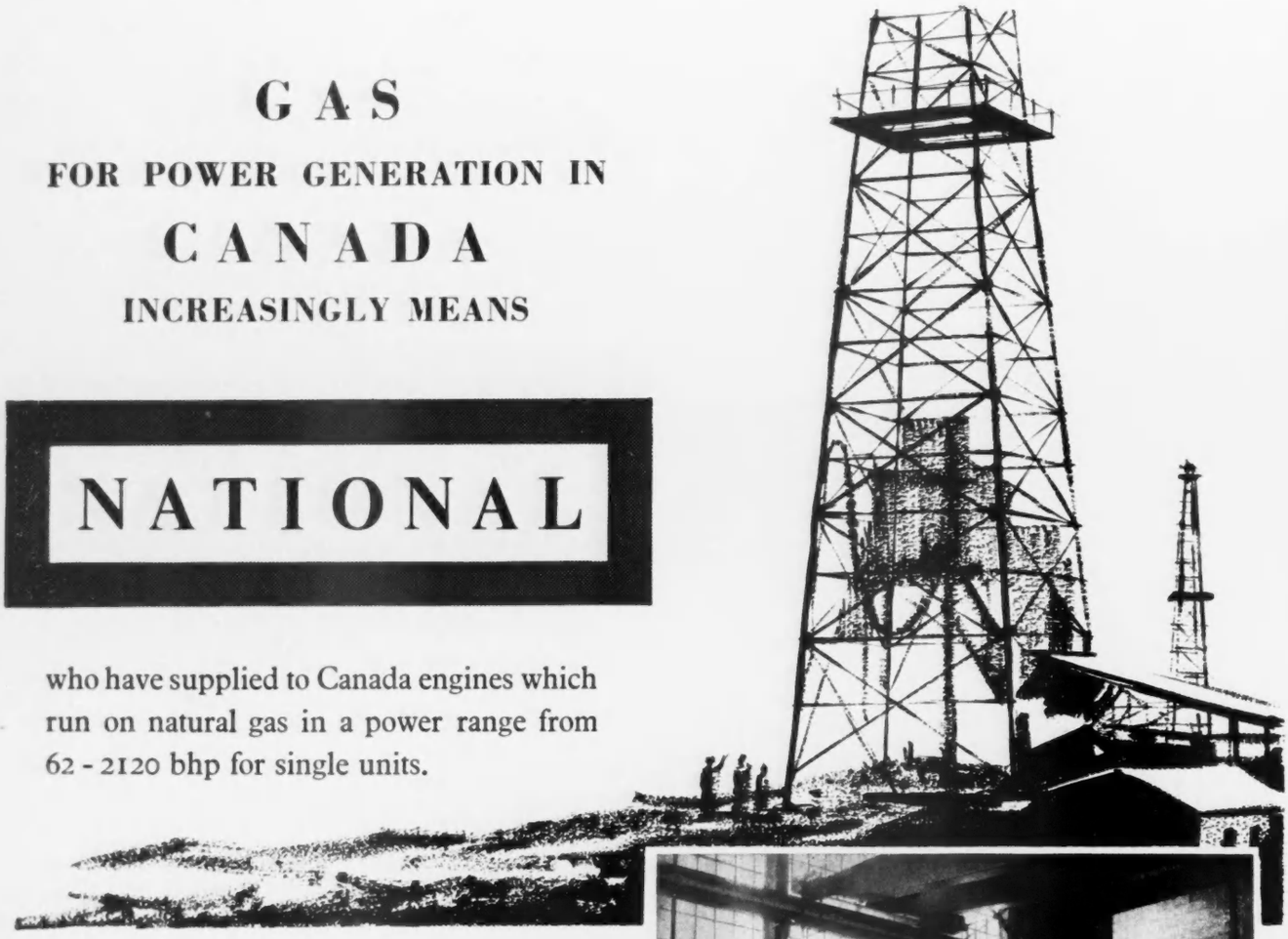

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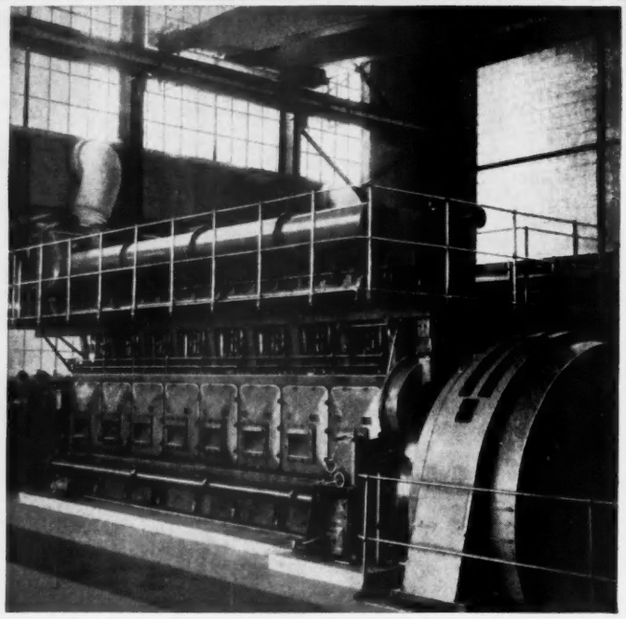

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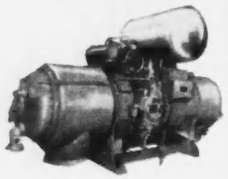

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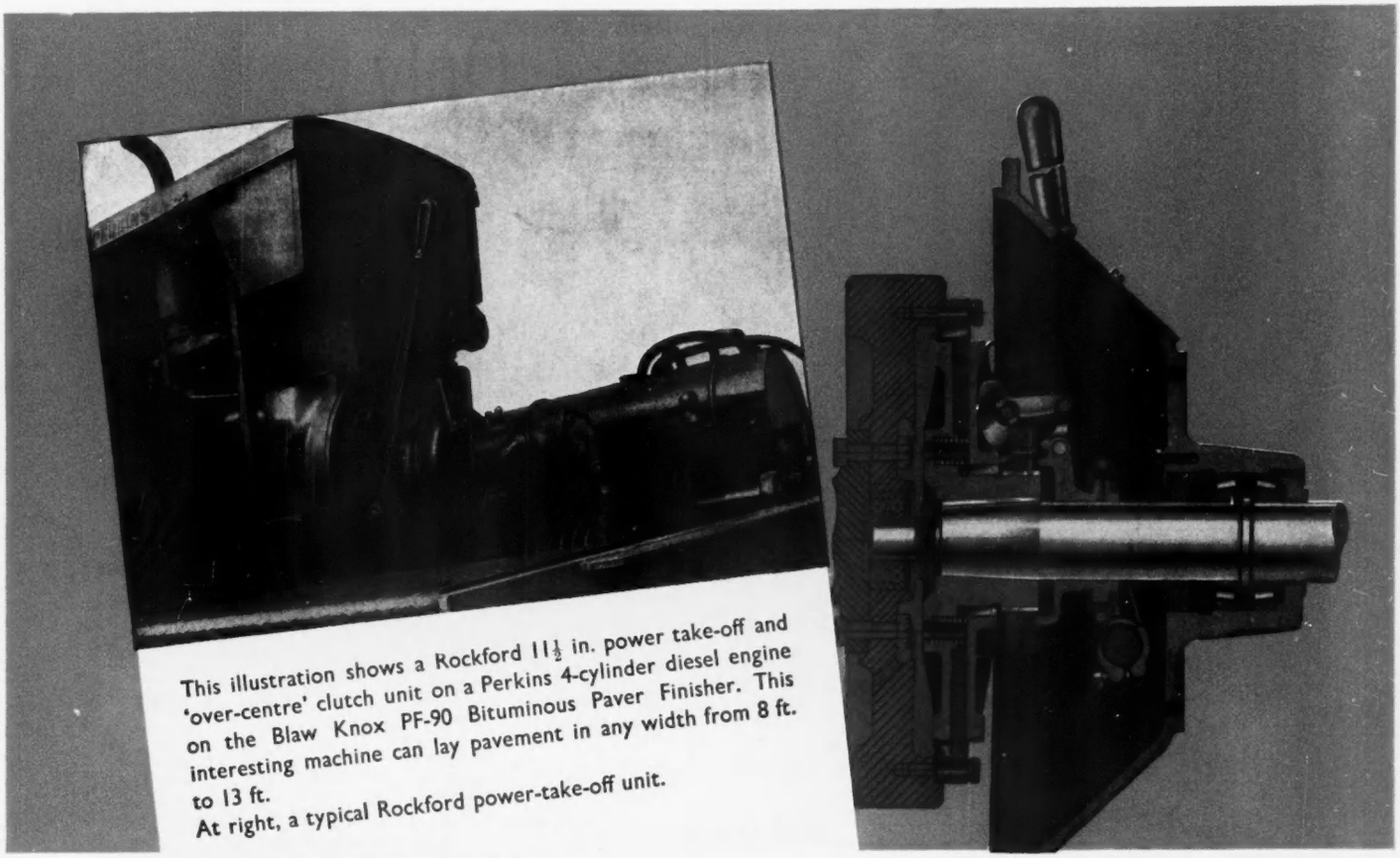
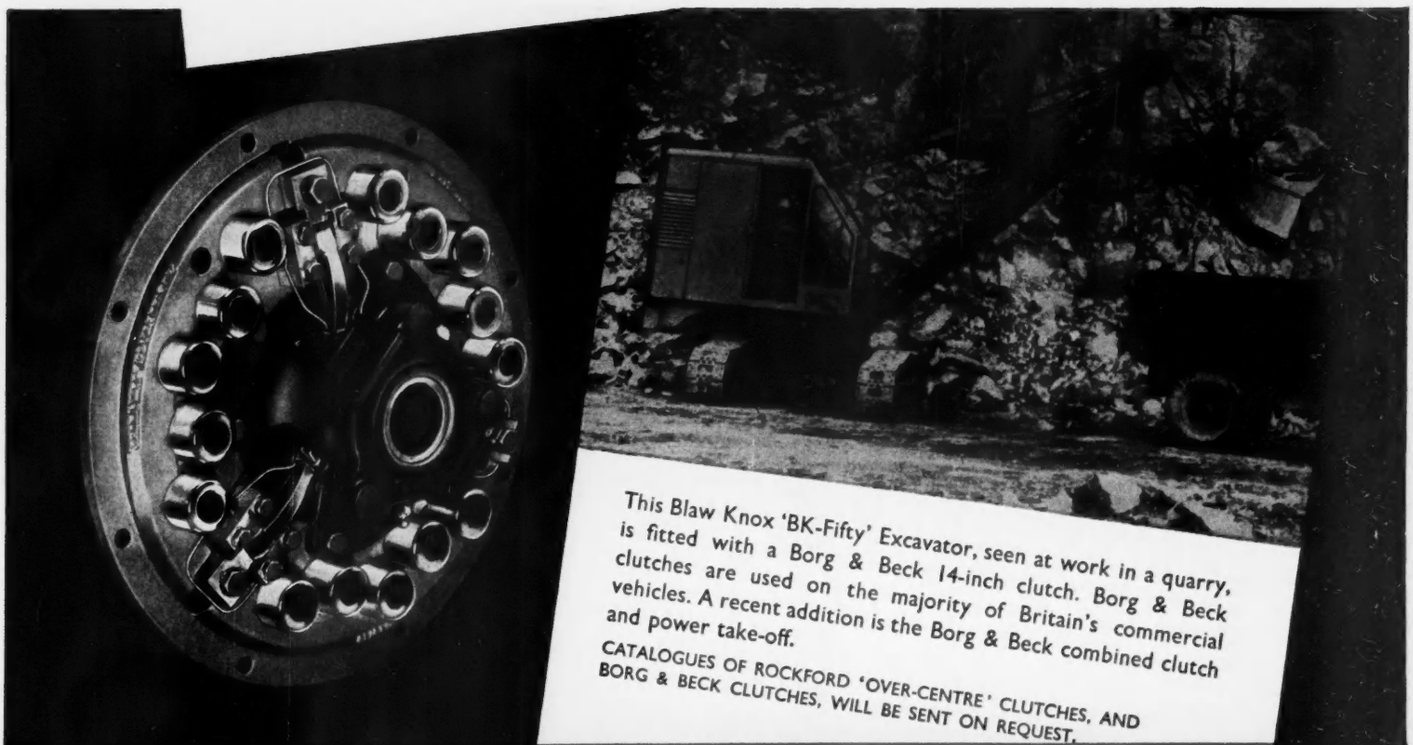


This illustration shows a Rockford 11½ in. power take-off and 'over-centre' clutch unit on a Perkins 4-cylinder diesel engine on the Blaw Knox PF-90 Bituminous Paver Finisher. This interesting machine can lay pavement in any width from 8 ft. to 13 ft.
At right, a typical Rockford power-take-off unit.

ROCKFORD CLUTCHES & POWER TAKE-OFFS



This Blaw Knox 'BK-Fifty' Excavator, seen at work in a quarry, is fitted with a Borg & Beck 14-inch clutch. Borg & Beck clutches are used on the majority of Britain's commercial vehicles. A recent addition is the Borg & Beck combined clutch and power take-off.

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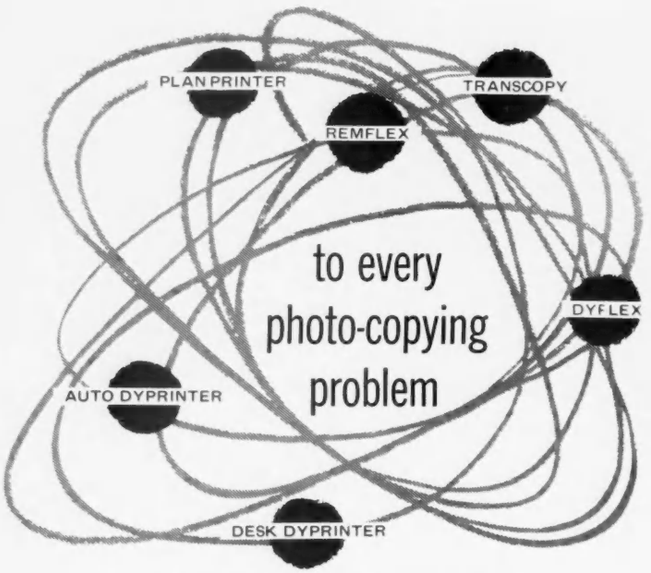

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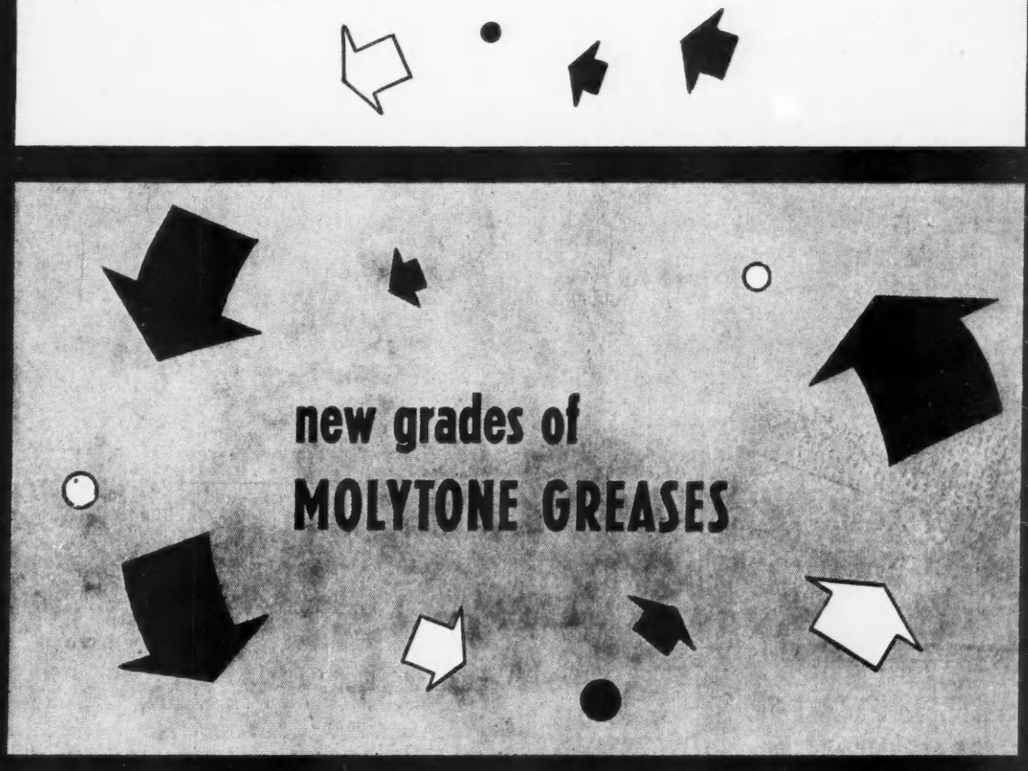

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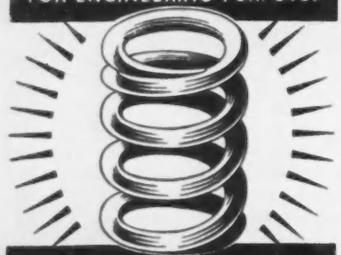

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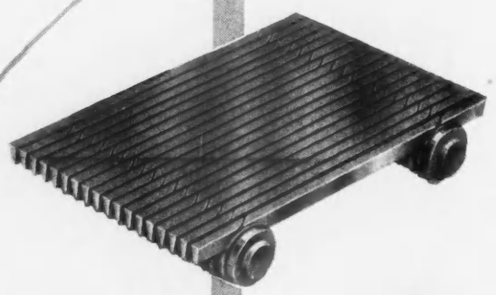

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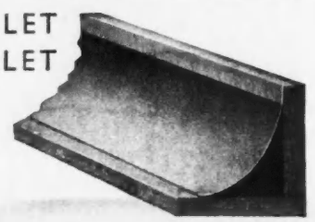

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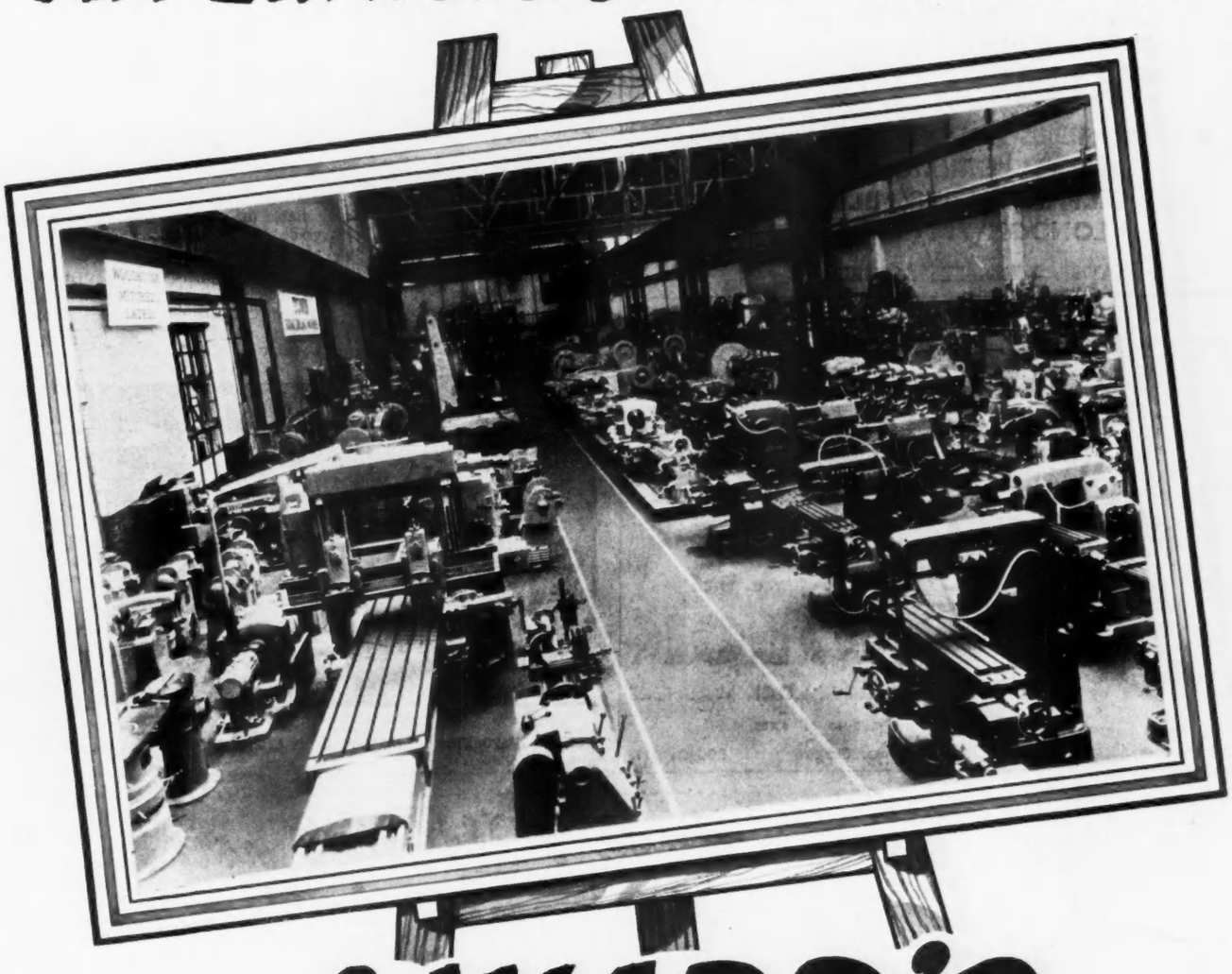

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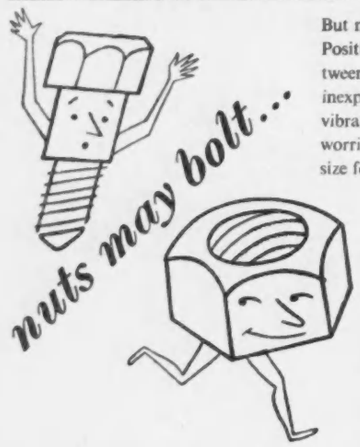

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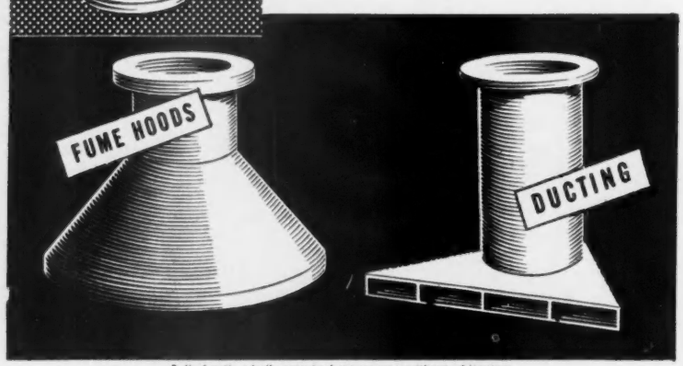

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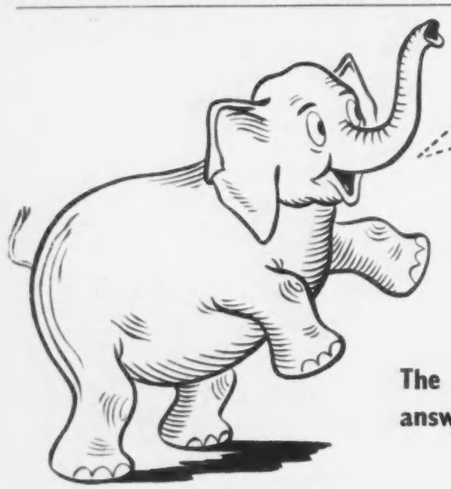

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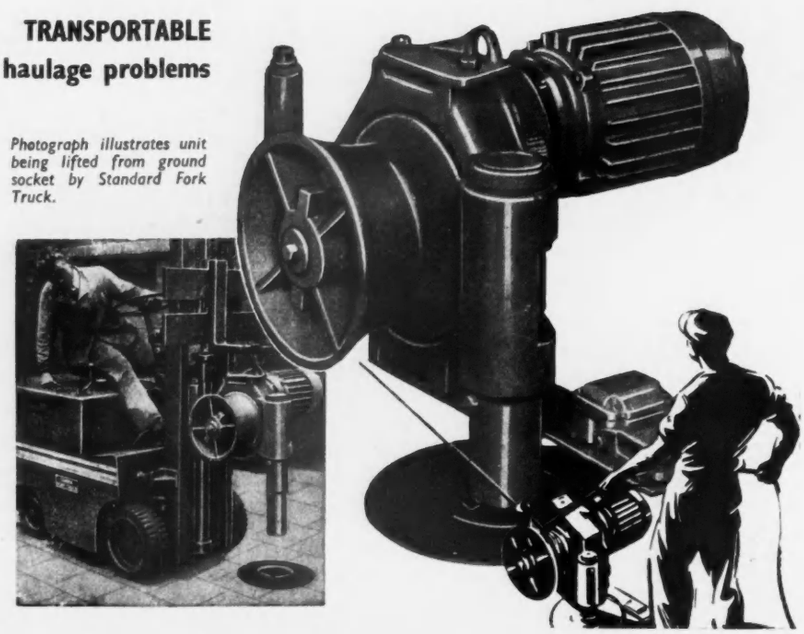

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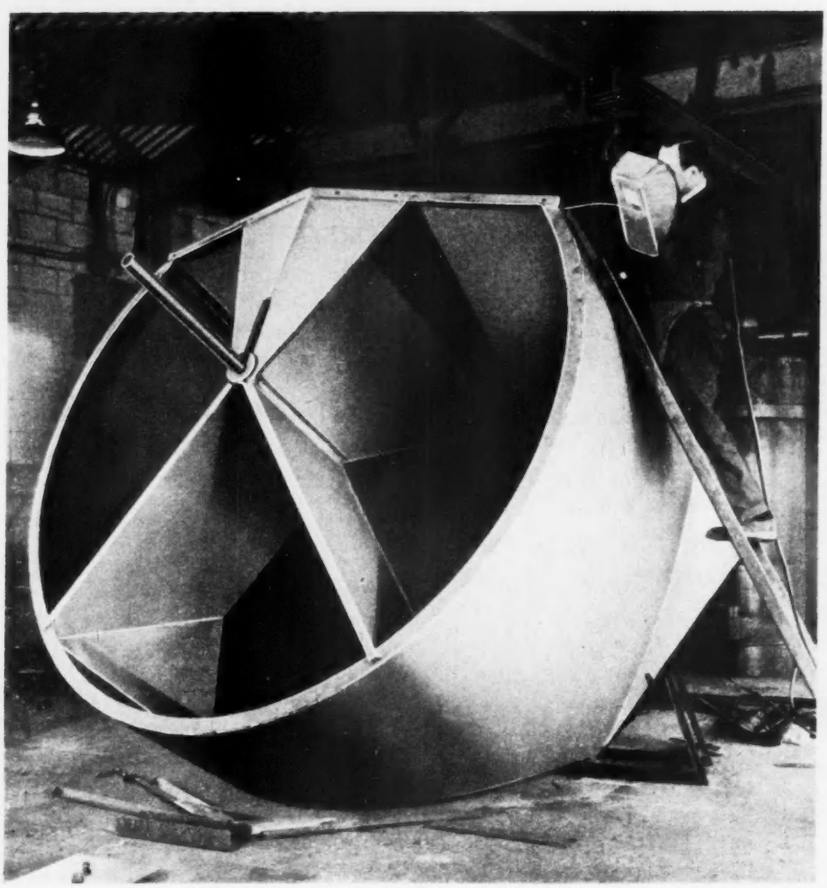

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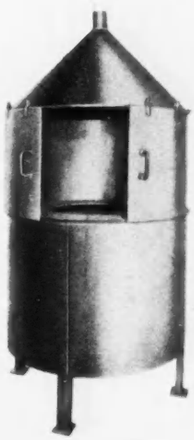

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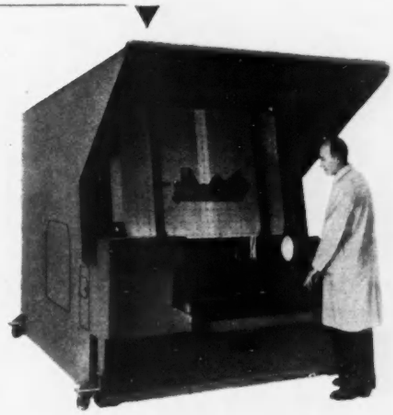

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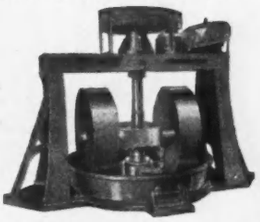

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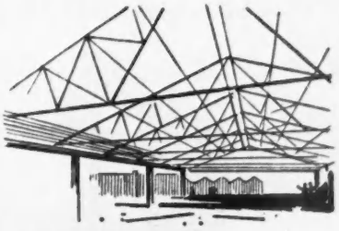

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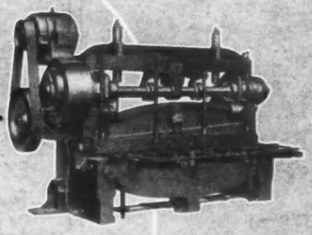

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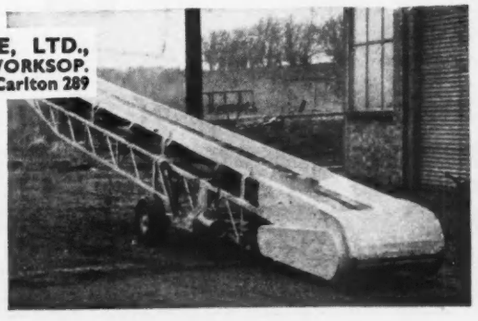

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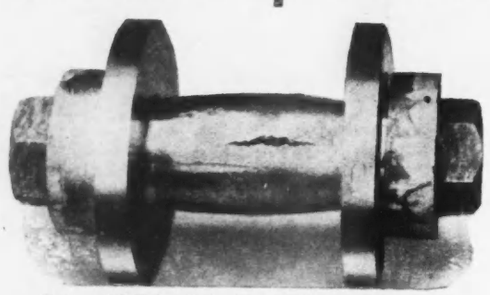
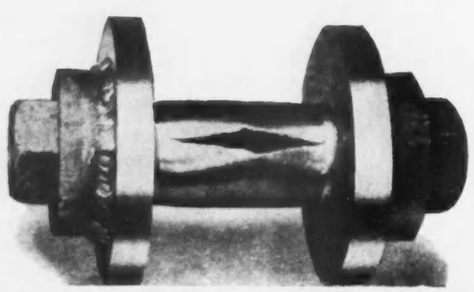


Gun-metal **0·25 in.** *thick—burst at* 4480. *lbs. per sq. in.*



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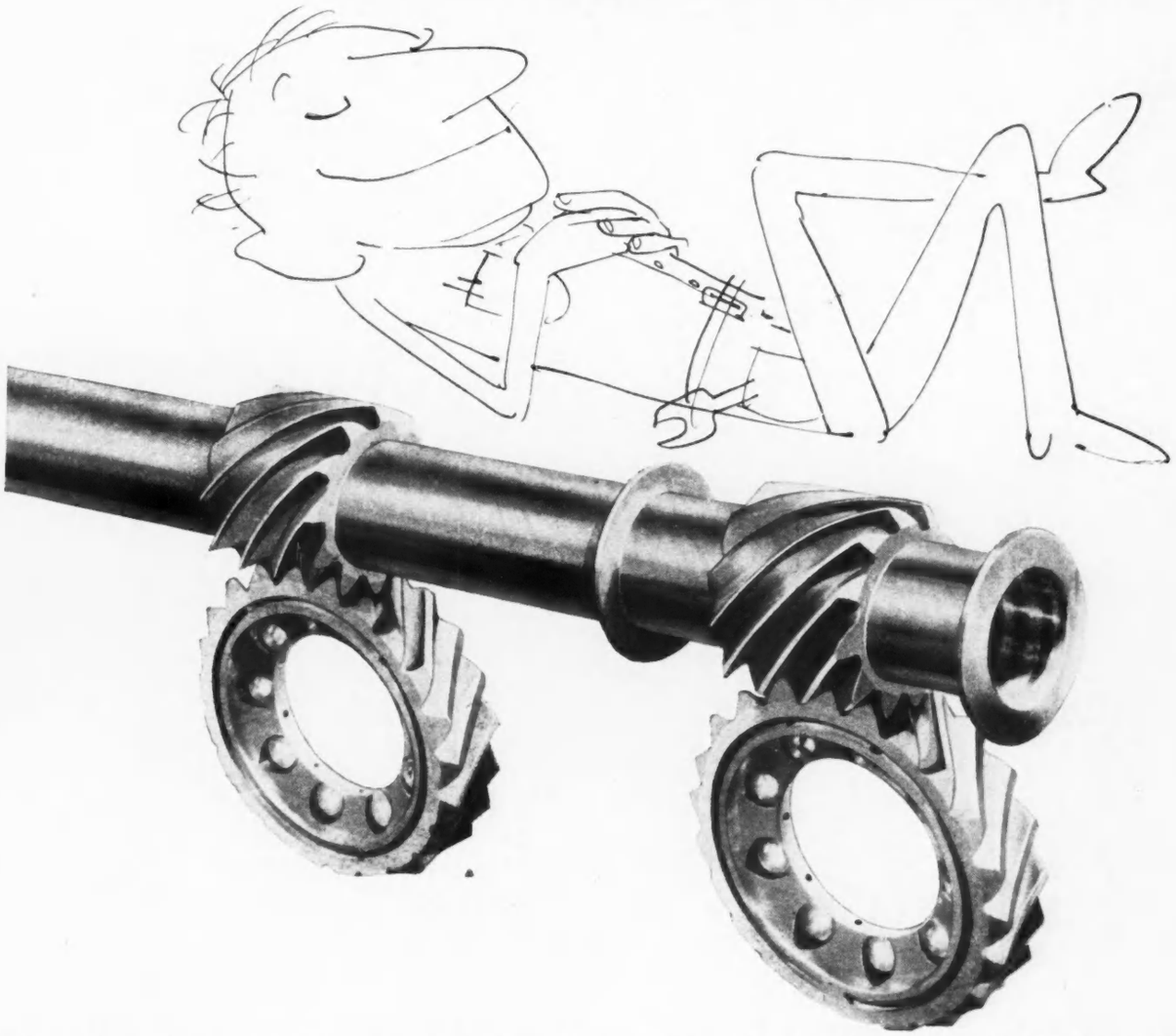

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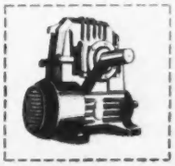

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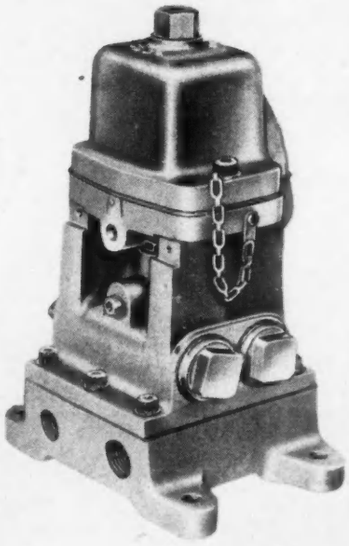

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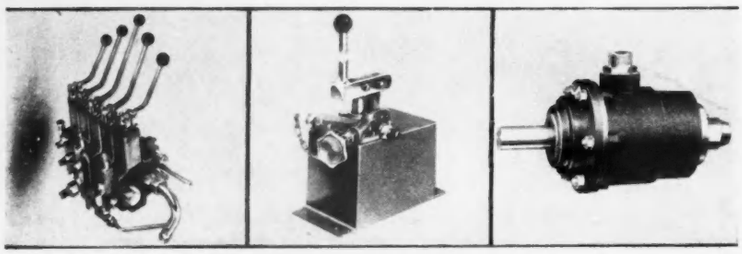

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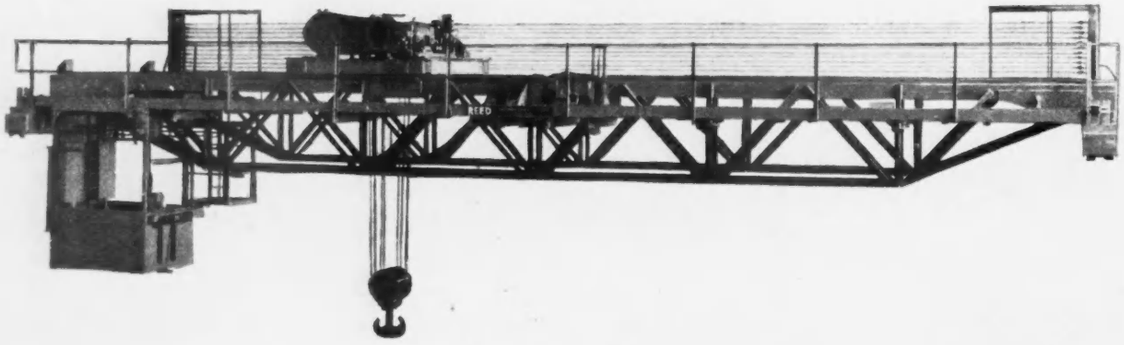

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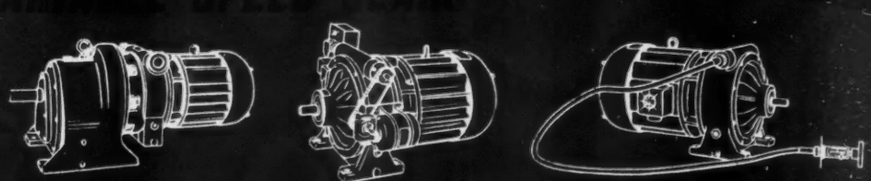

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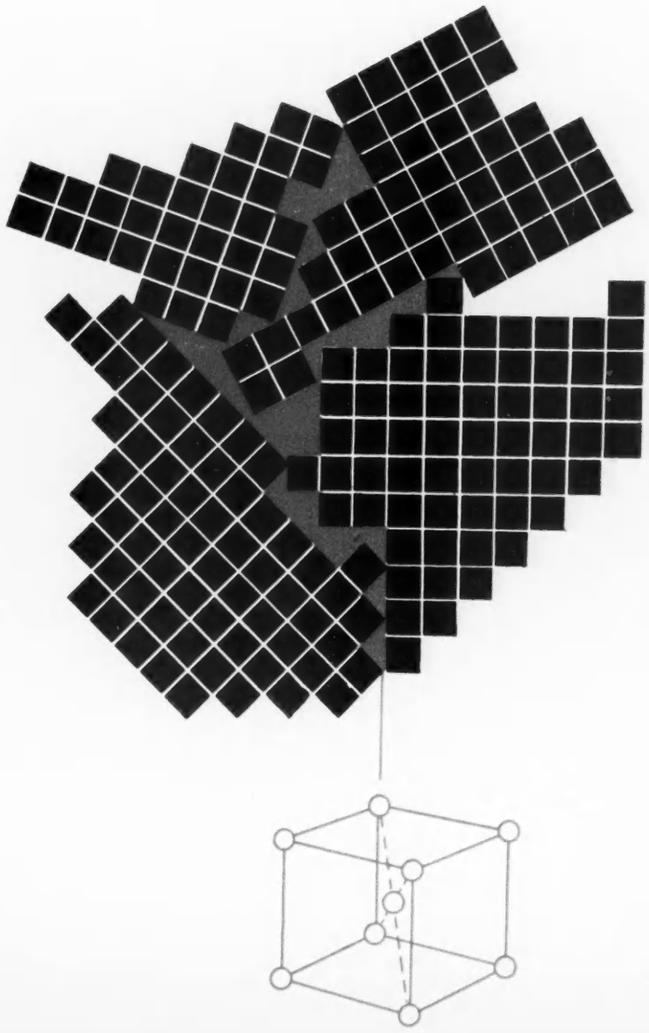
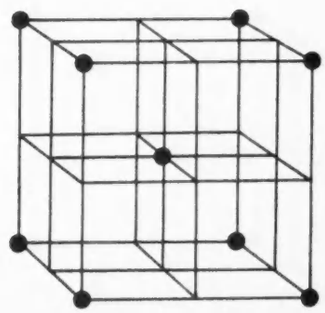
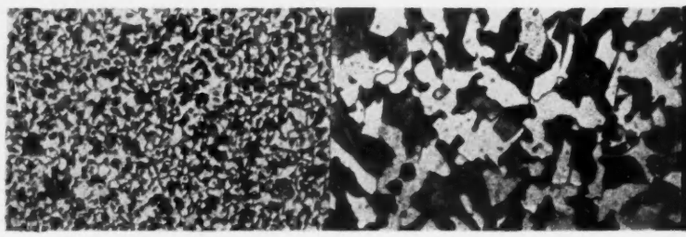




a b



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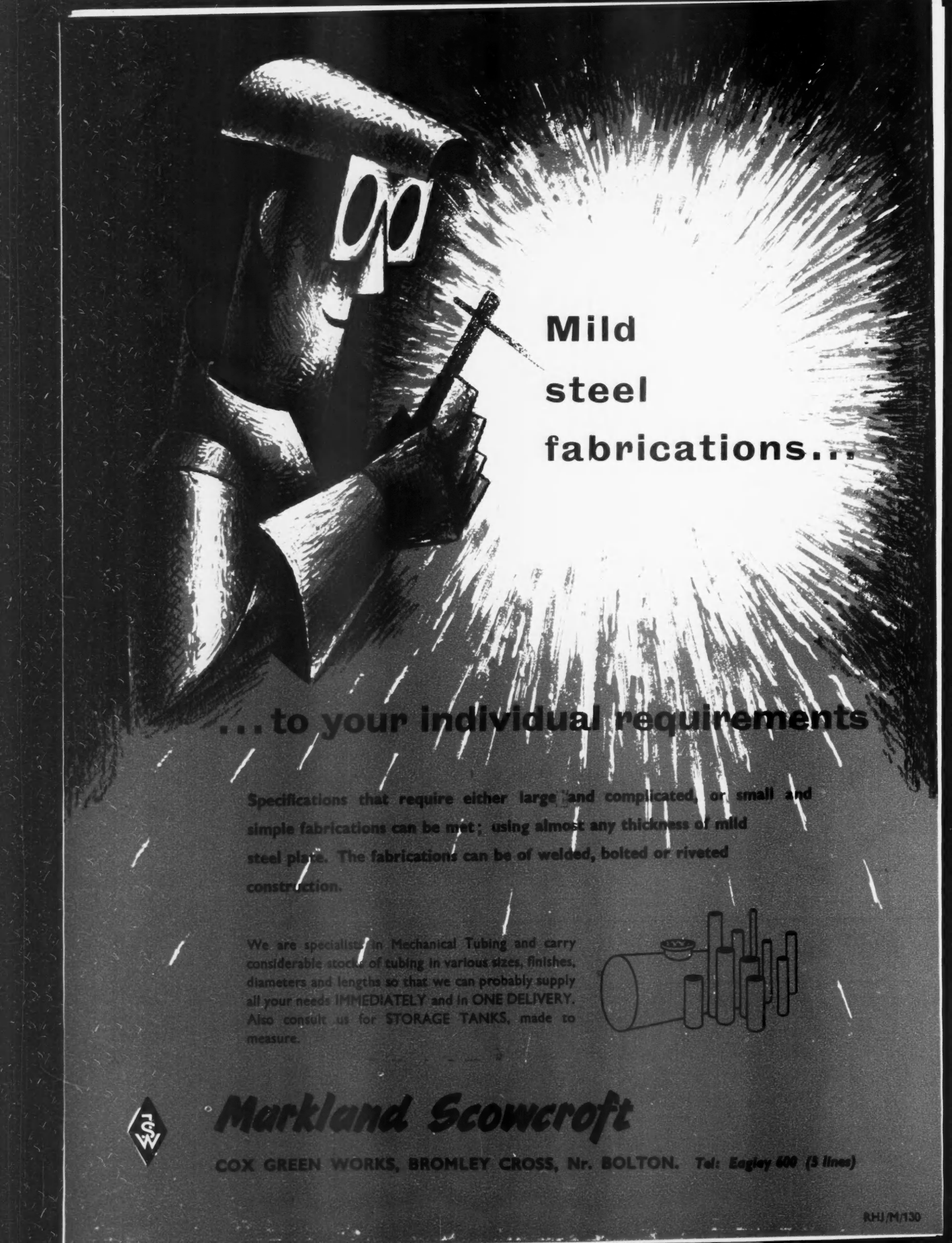
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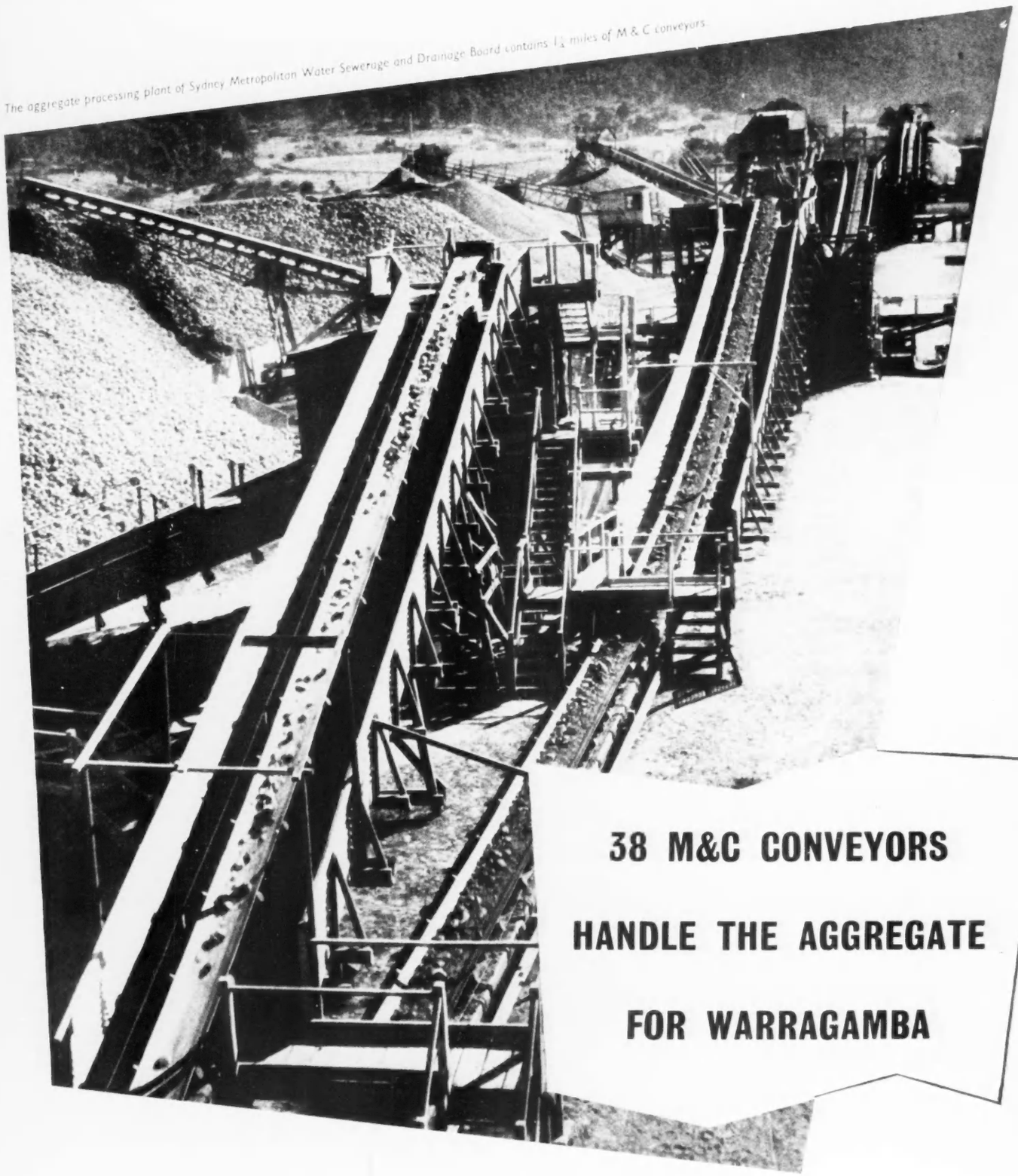
The aggregate processing plant of Sydney Metropolitan Water Sewerage and Drainage Board contains 1¾ miles of M & C conveyors.



38 M&C CONVEYORS HANDLE THE AGGREGATE FOR WARRAGAMBA

The largest concrete dam in the southern hemisphere will ensure the water supply of Sydney for the next fifty years. To provide the aggregate for it, gravel containing boulders up to 24 in. long is being carefully processed, and stocked above reclaiming tunnels in ten grades of round and crushed stone and sand. In this great and complicated plant, reliability is essential. The handling throughout is by M&C belt conveyors and by radial stackers using M&C idlers. M&C plant has again justified its choice, for trouble-free working on an arduous task over a long period.

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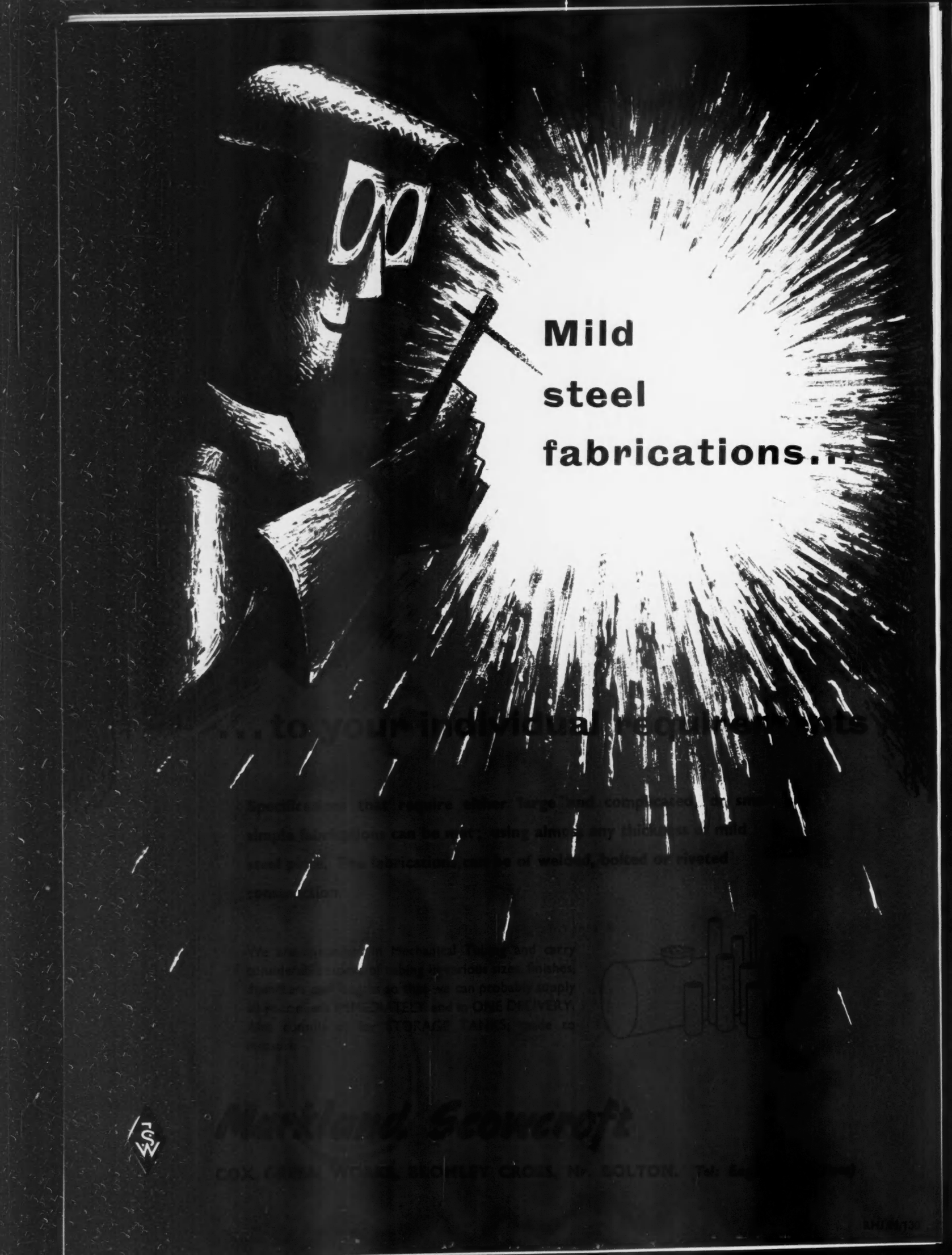
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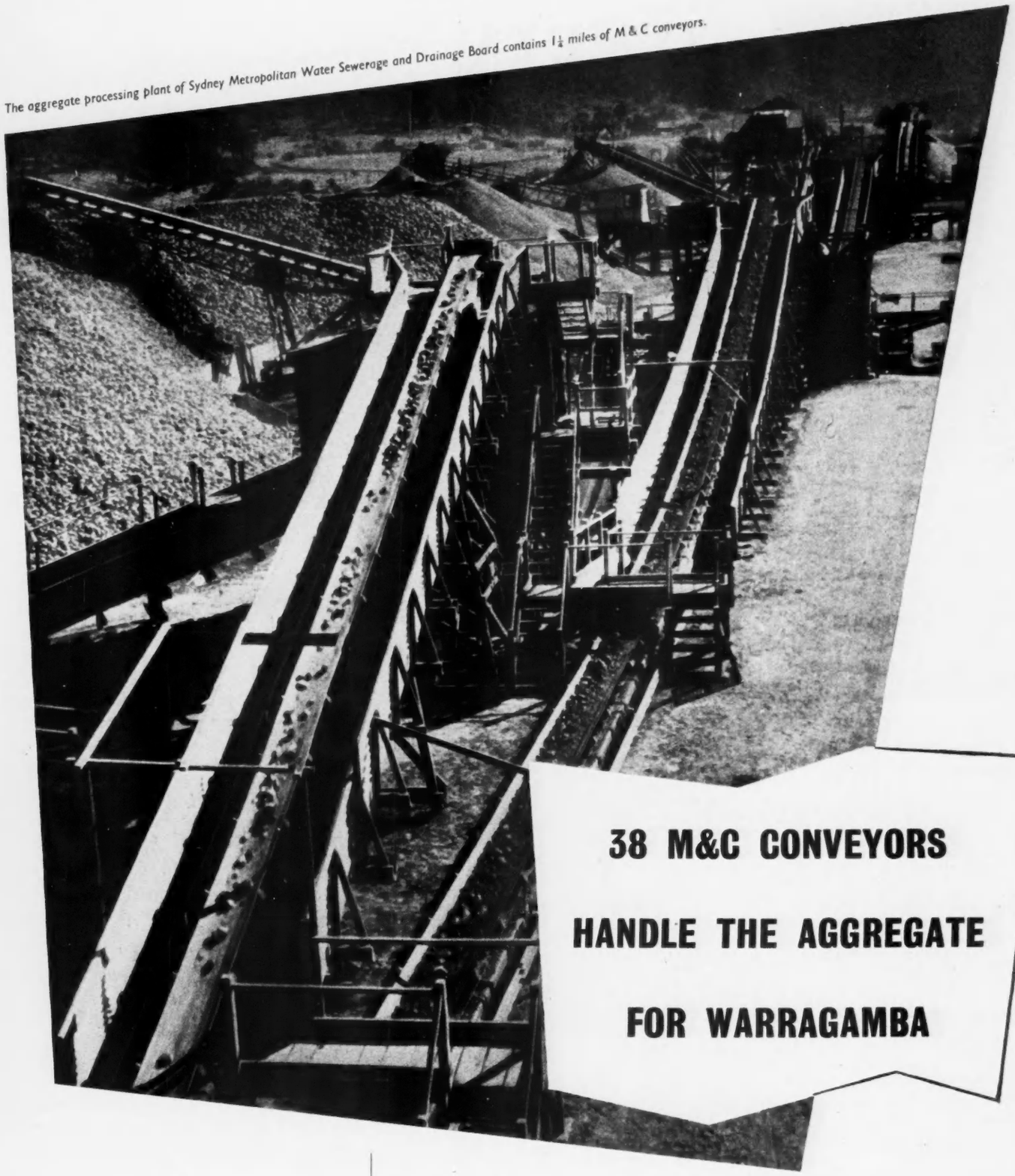

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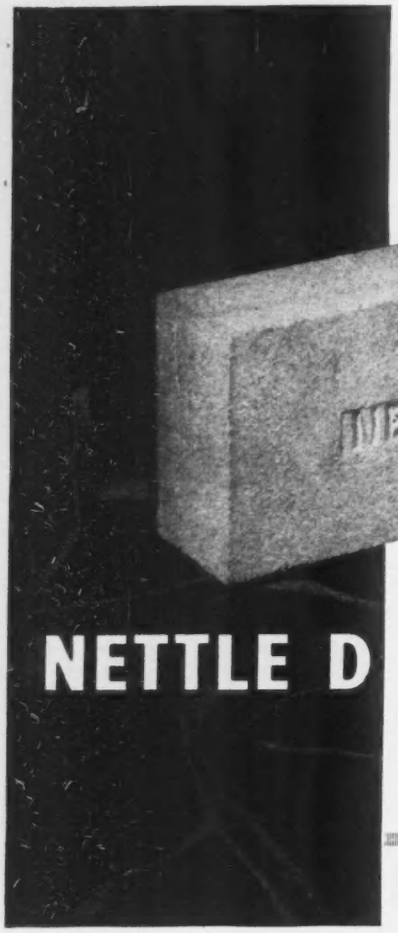

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The supply and installation of these sidings and the adjoining trackwork for the new Coal Carbonization and Benzole Rectification Schemes were entrusted to the Eagre Construction Co., Ltd., by the National Coal Board. Over 9,000 tons of Iron and Steel were used in the construction of the forty miles of track and 230 turnouts and Special Point and Crossing layouts comprising the combined railway Sidings.

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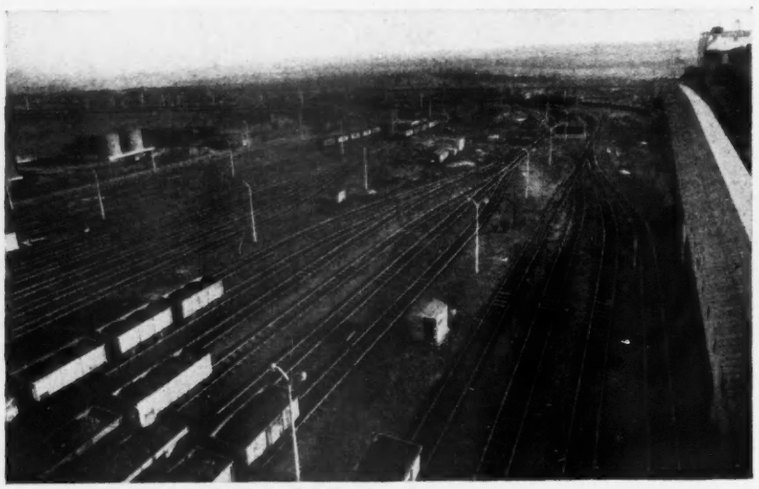
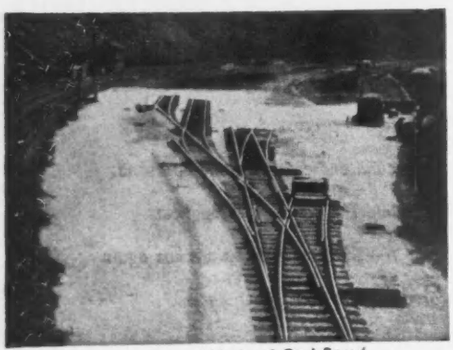
The National Coal Board again entrusts the Eagre Construction Co. Ltd. with a similar project. Earthworks, Drainage, Track Laying and ancillary works for thirteen miles of Sidings are now in progress at Cadeby Main.



Photograph by courtesy of National Coal Board

for a complete Track Service



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In addition to its activities in the Nation's Coalfields, the Eagre Construction Co. Ltd. has worked continuously during the past ten years for British Railways, the Gas Board, the United Steel Companies, and has carried out large Power Station Projects for the Central Electricity Authority.

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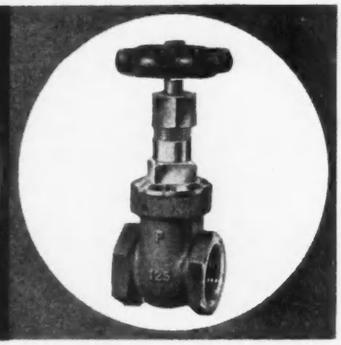

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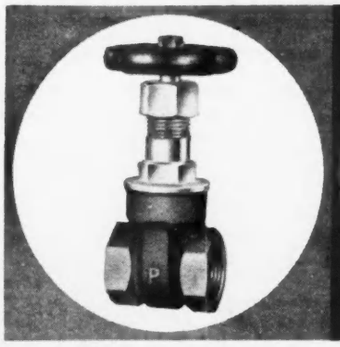

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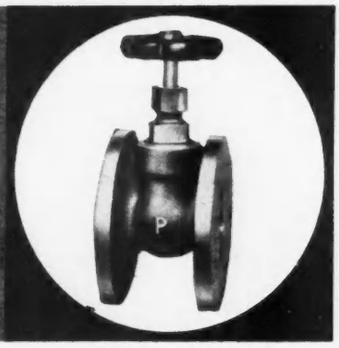

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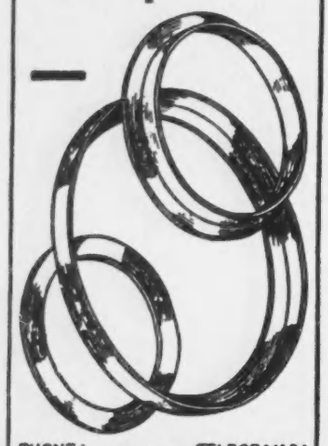

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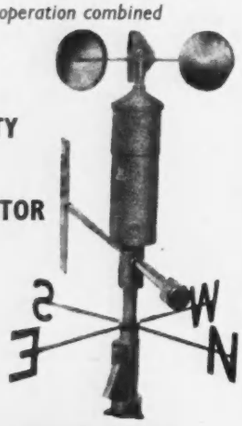

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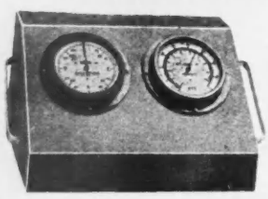

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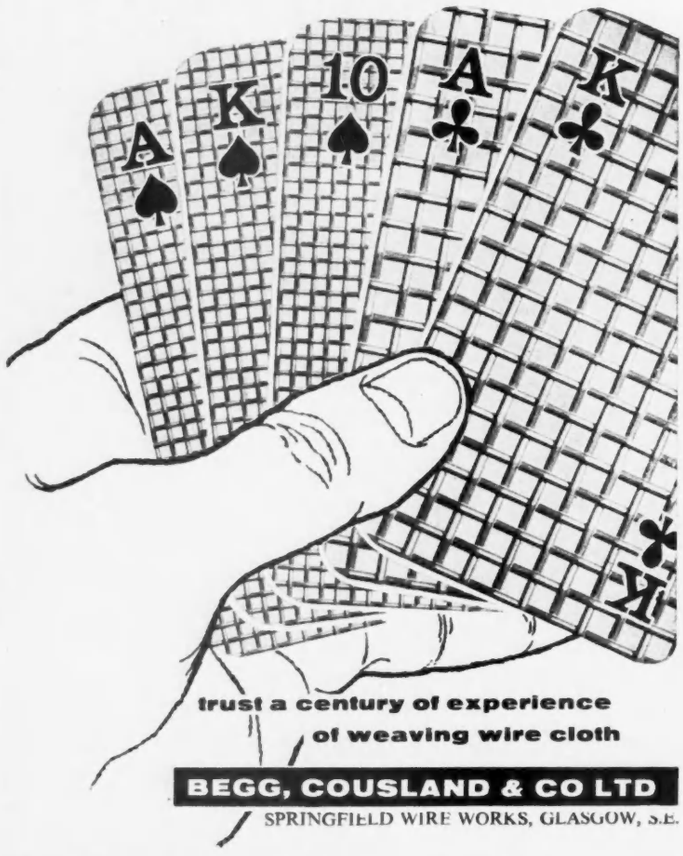

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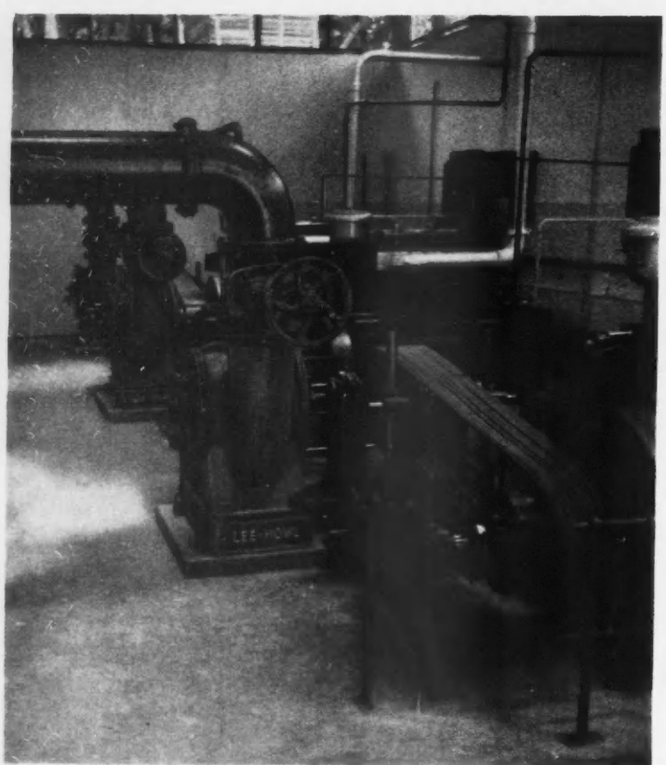

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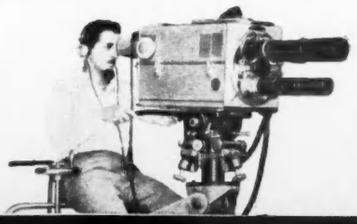
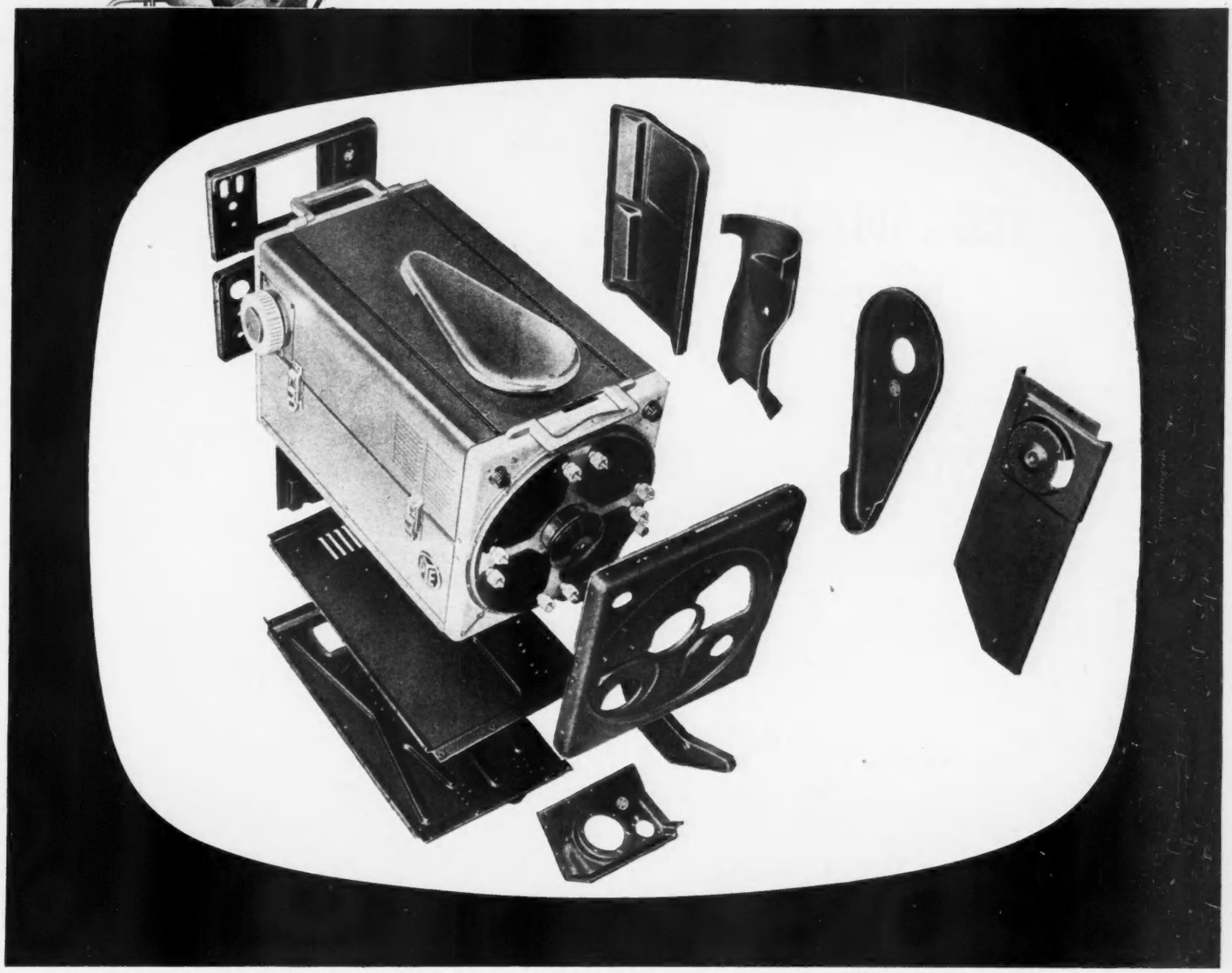


Pye had the light idea



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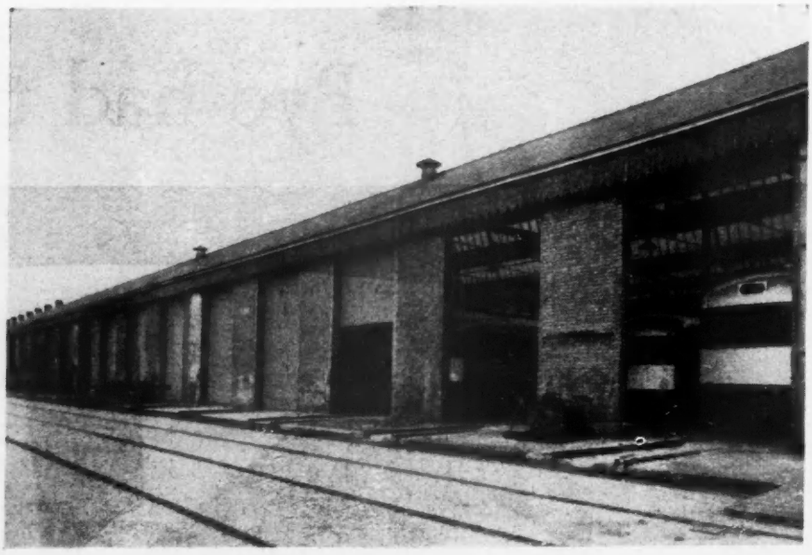

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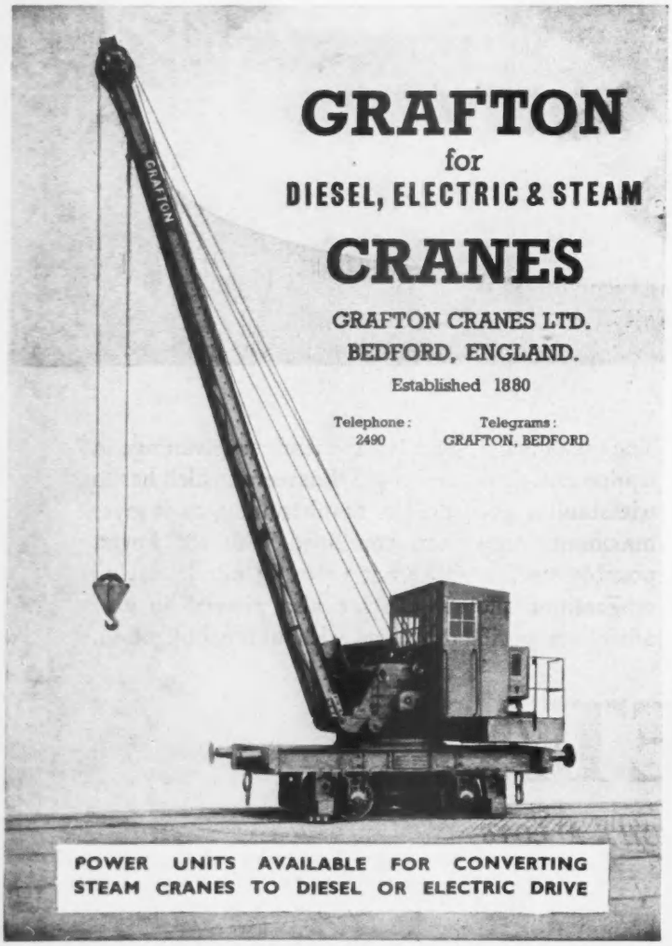

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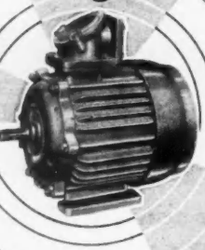

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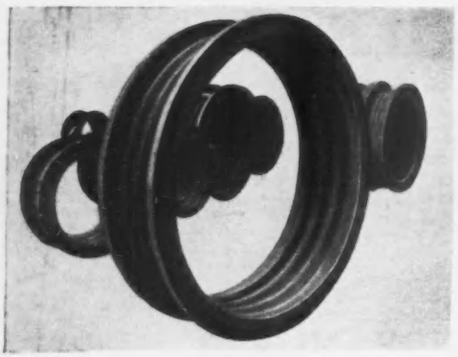

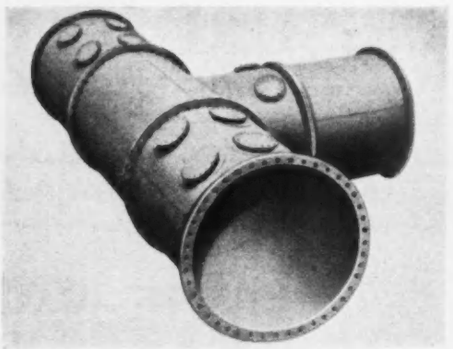

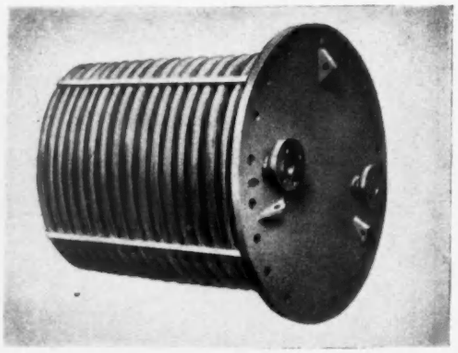

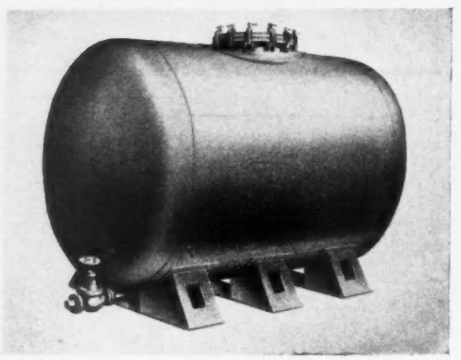

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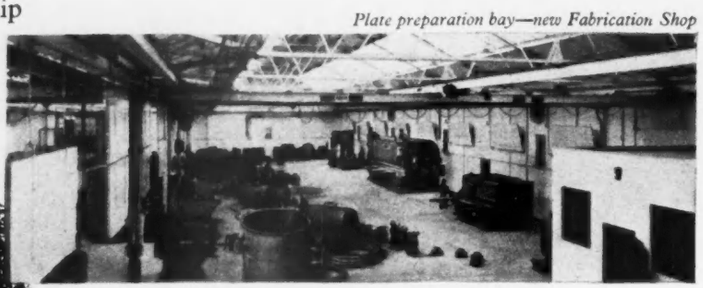

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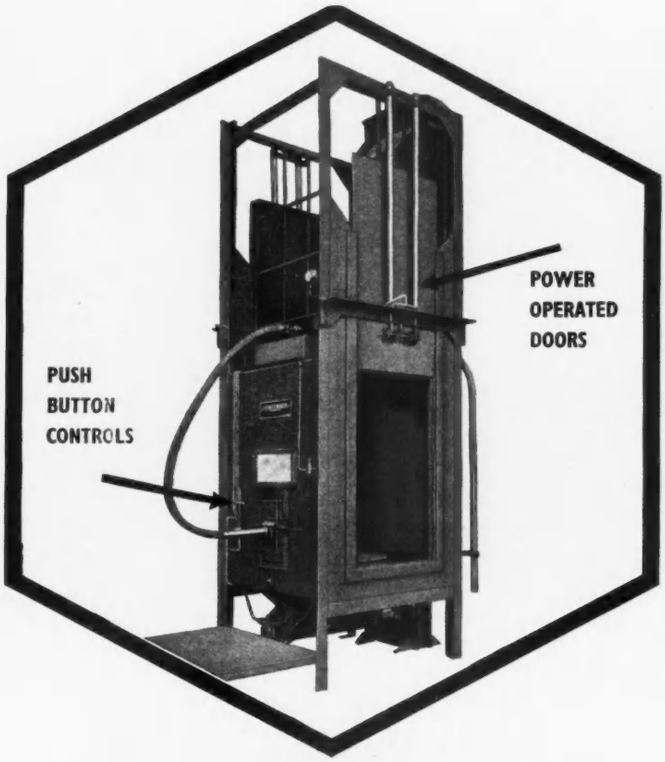

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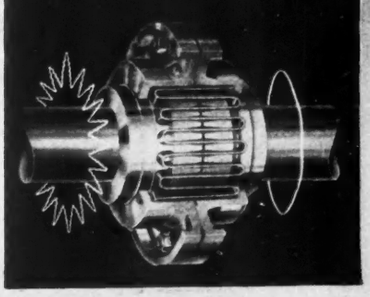

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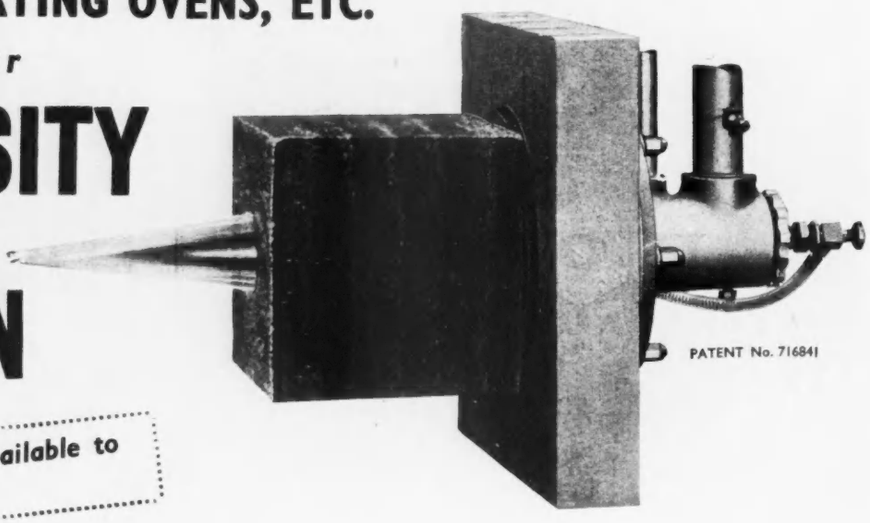

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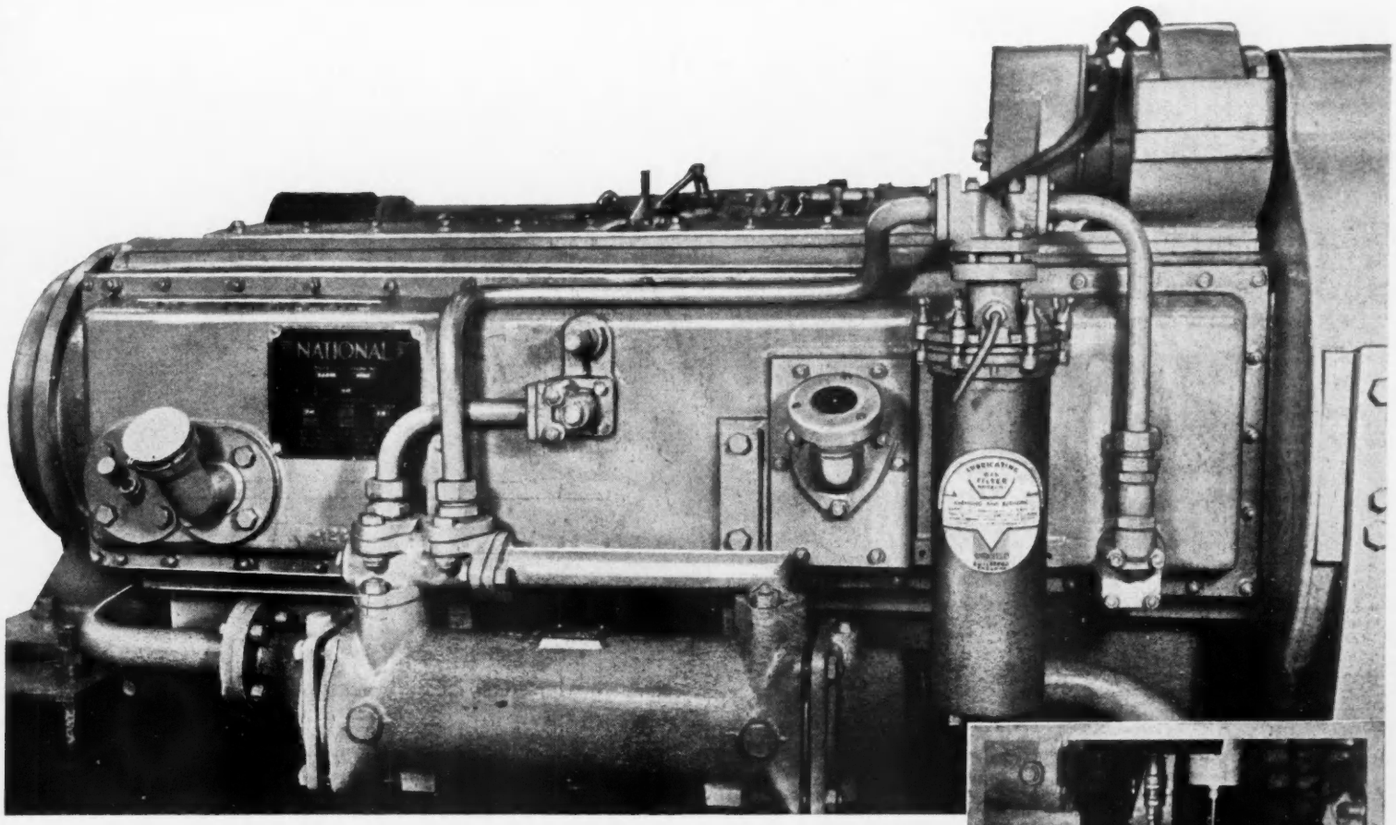
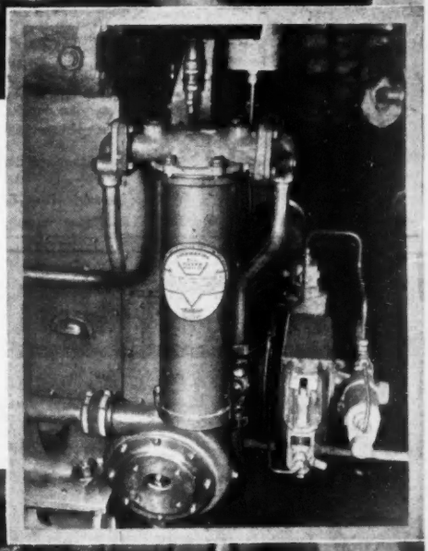


▲ *Vokes lubricating oil filter fitted on the new series of "NMH" normally aspirated, horizontal diesel engines.*



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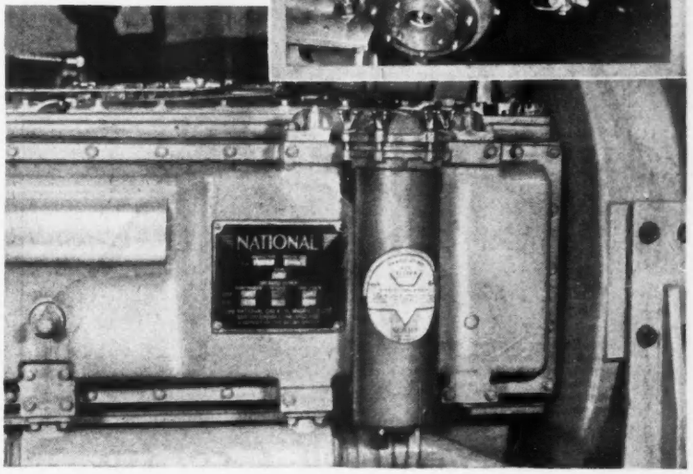

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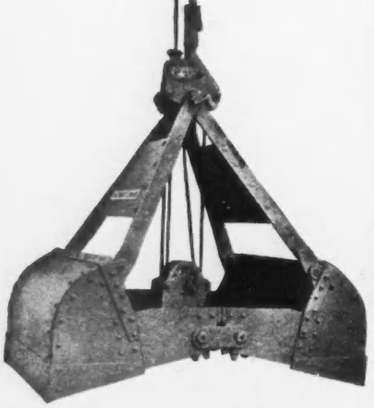

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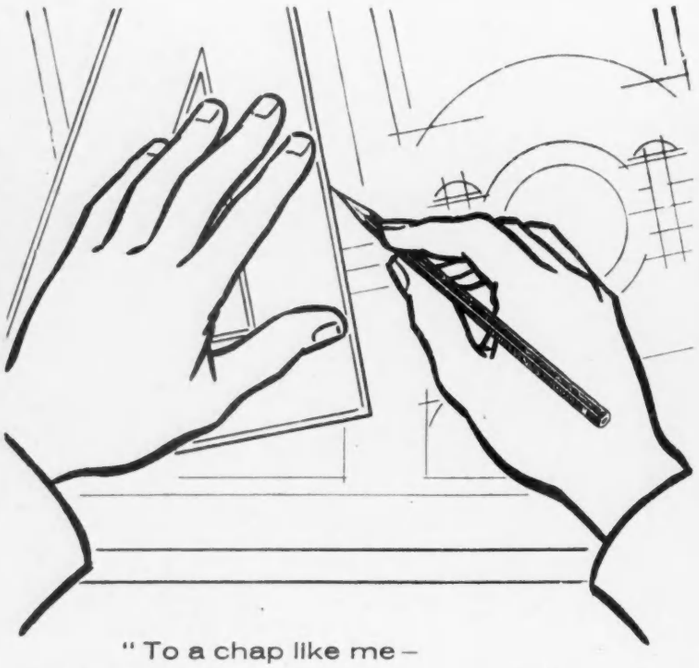

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and I'm proud of my work – my pencil's
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The pencils I use have to stand up to fast
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and flow smoothly throughout a long line –
no crumbling or 'clinkers' mark you! –
and if I erase a line it must go cleanly –
there's no 'furrow' left in my paper
so you won't find ghost lines in prints
made off my drawings. As a matter of
fact you can tell from a print when it is
my drawing – the print's always first class".

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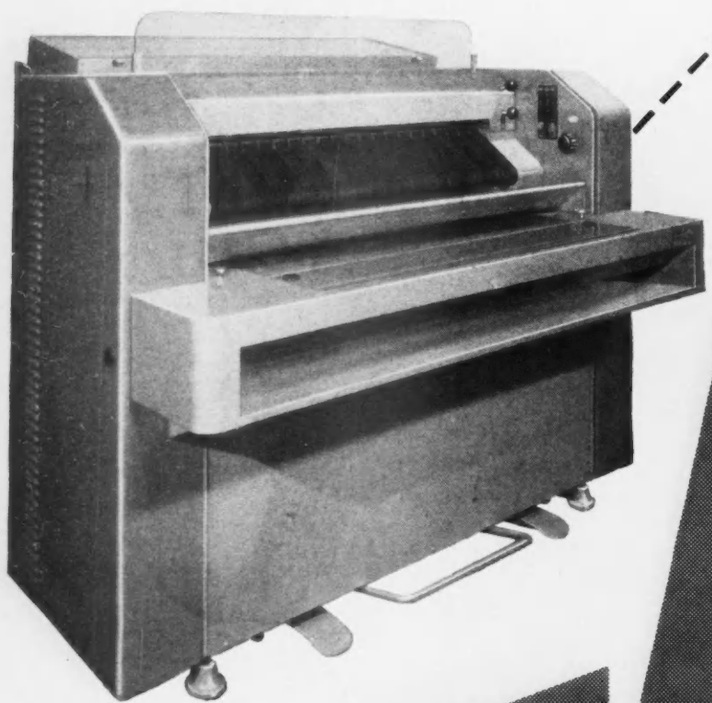

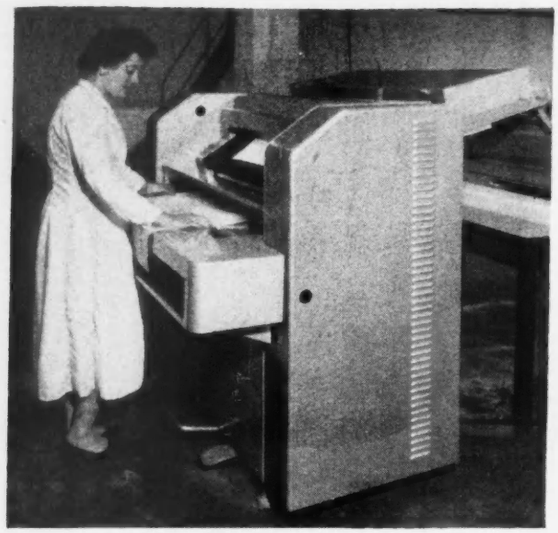

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- All controls conveniently located for rapid, effortless adjustment.
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- Complete design co-ordinated for exceptionally high potential output.
- Excellent mechanical layout giving silent, vibrationless running.
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Printing speed: from 2 ft. to 30 ft. per minute.
Lamp: H.P.M.V. quartz, 3,000 watt.
Dimensions: height, 58 in., width, 72 in., depth (tray extended) 80 in.
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Subject to certain conditions, the majority of AZOFLEX photoprinting machines can be hired as an alternative to outright purchase.

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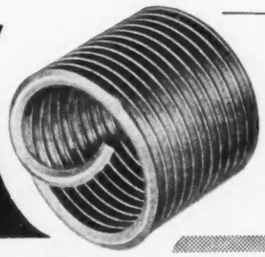

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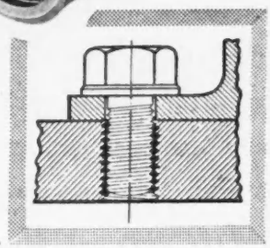

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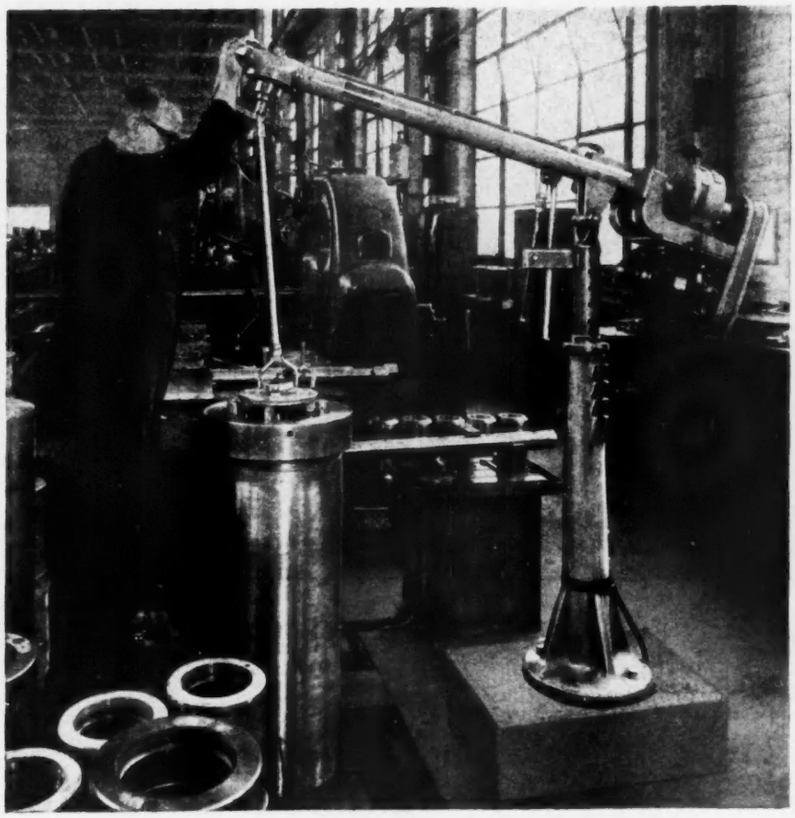

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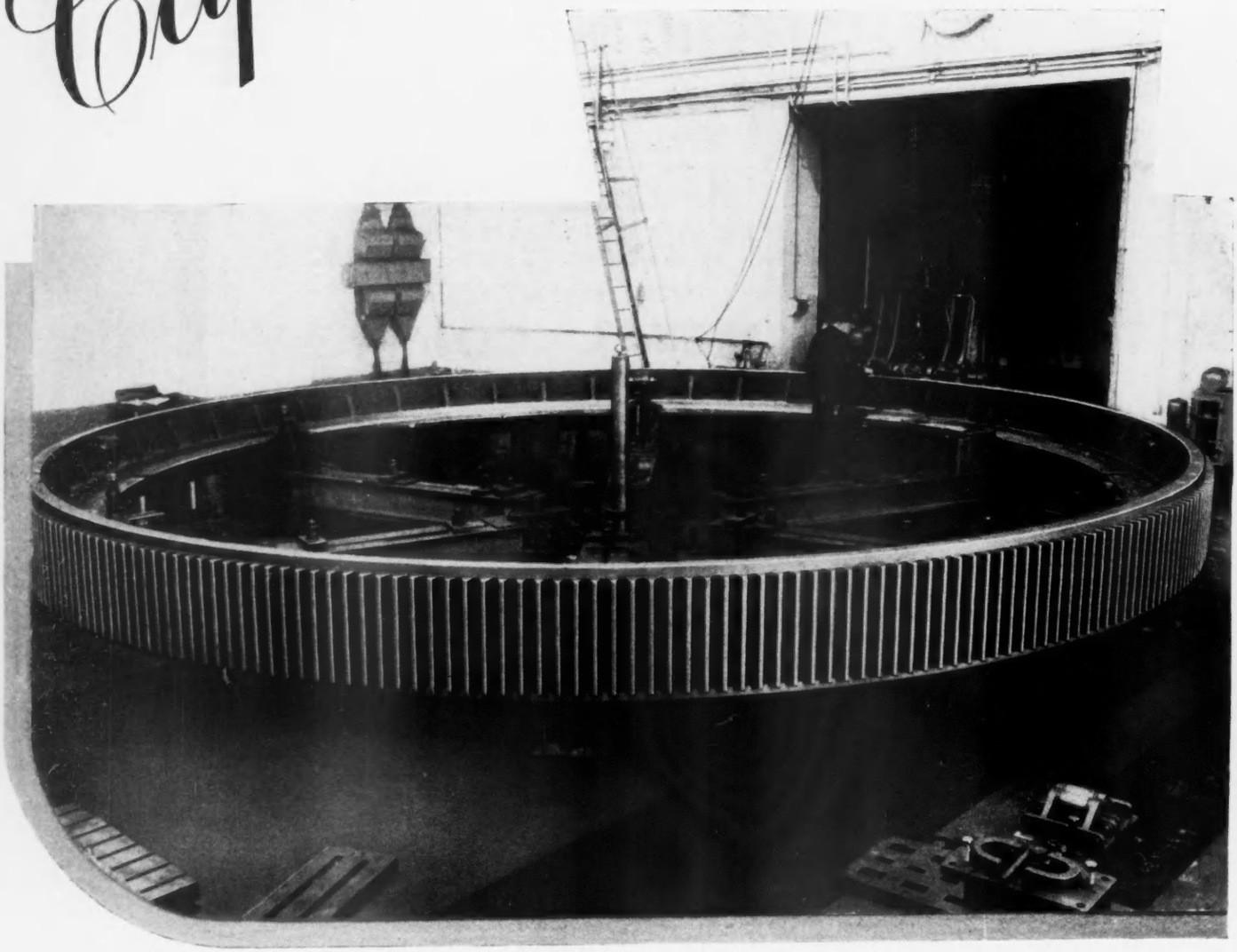

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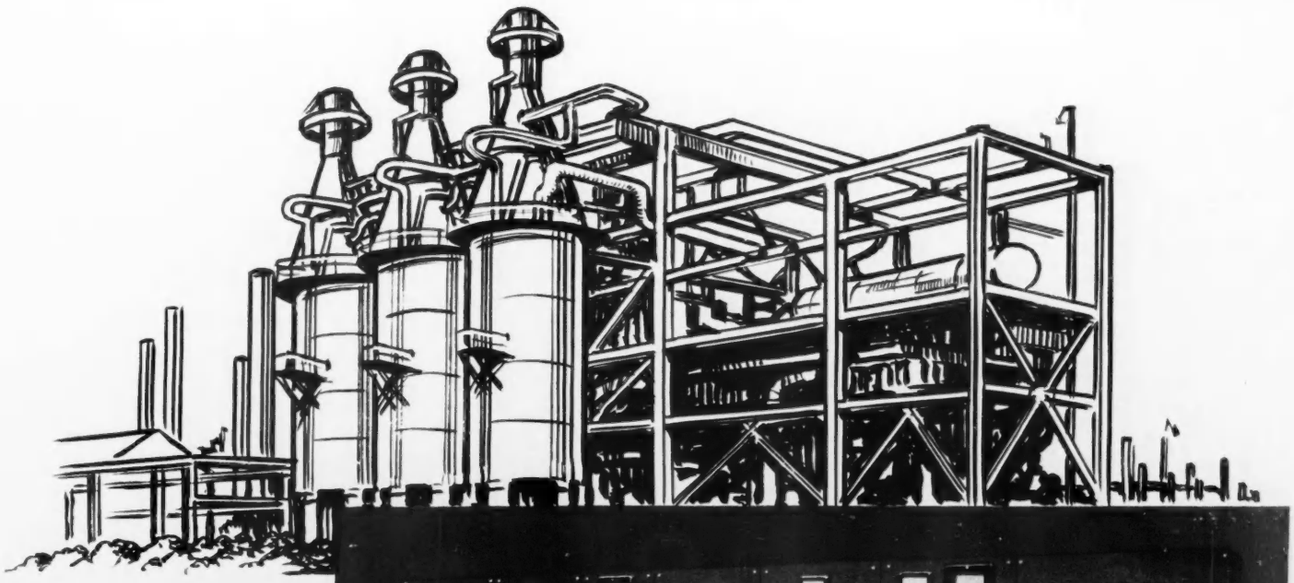

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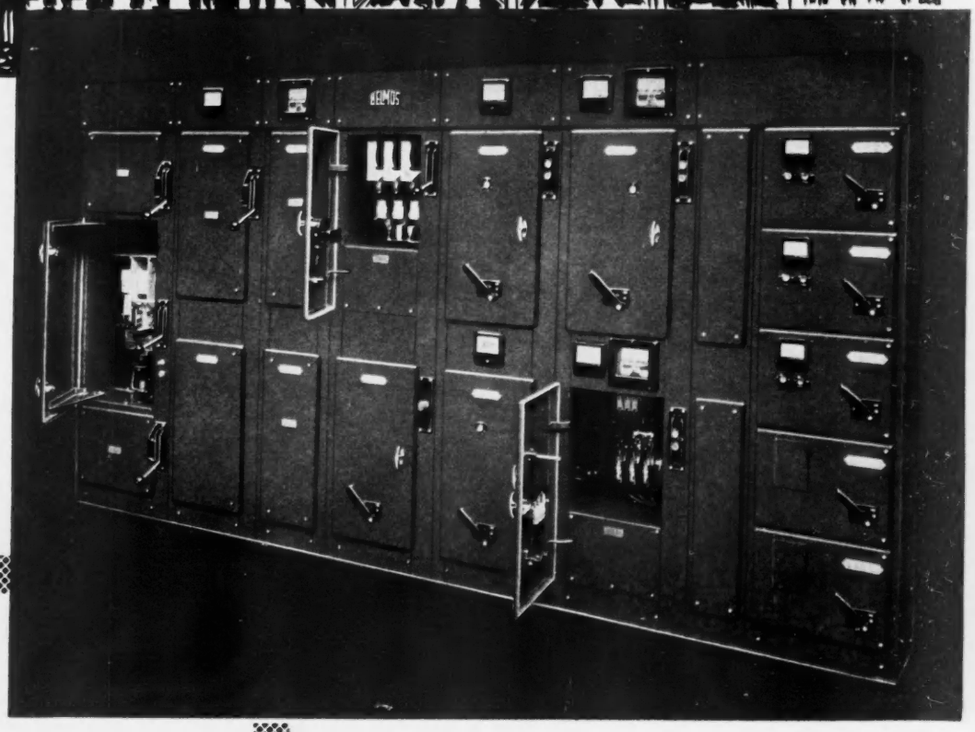

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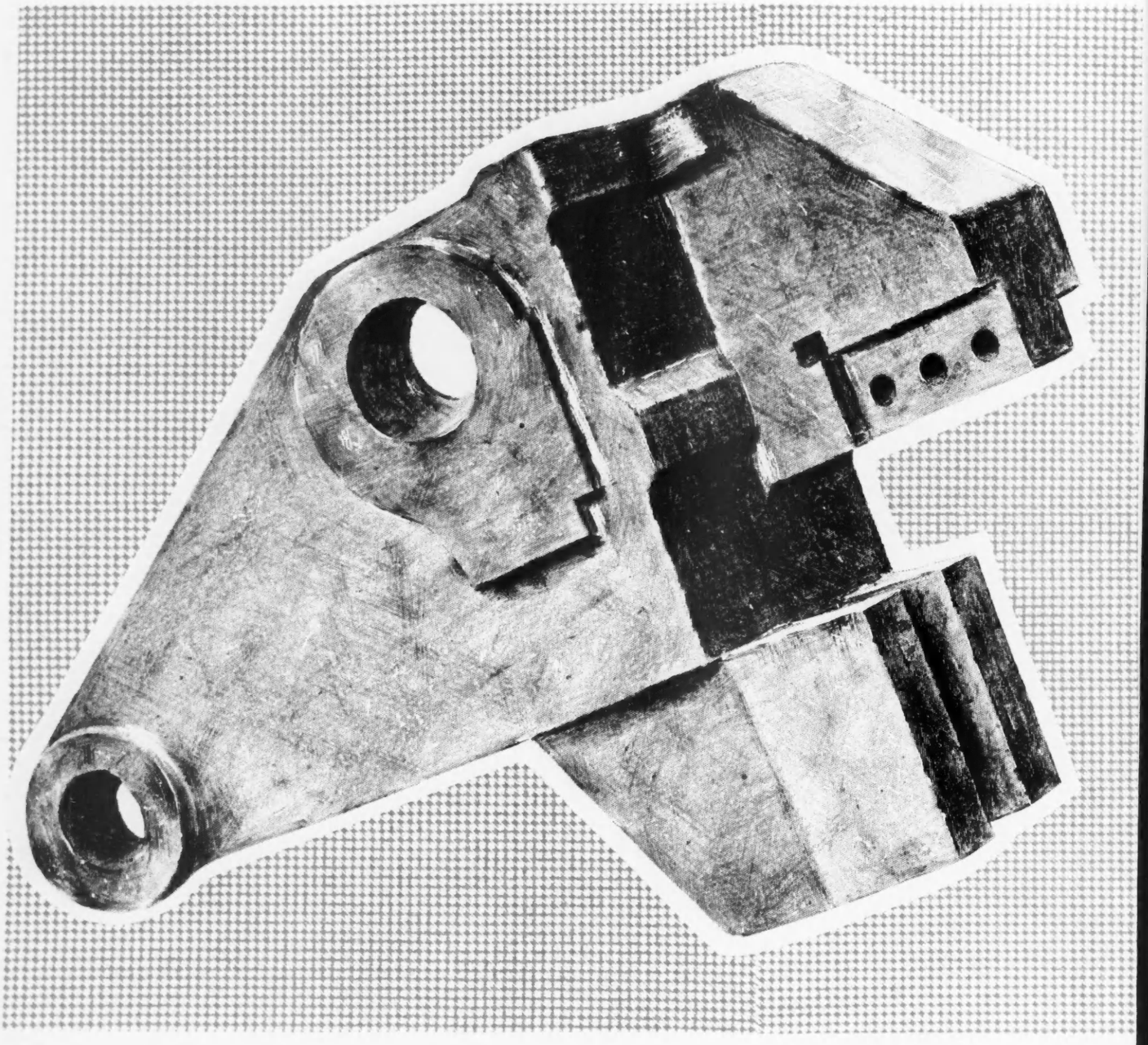

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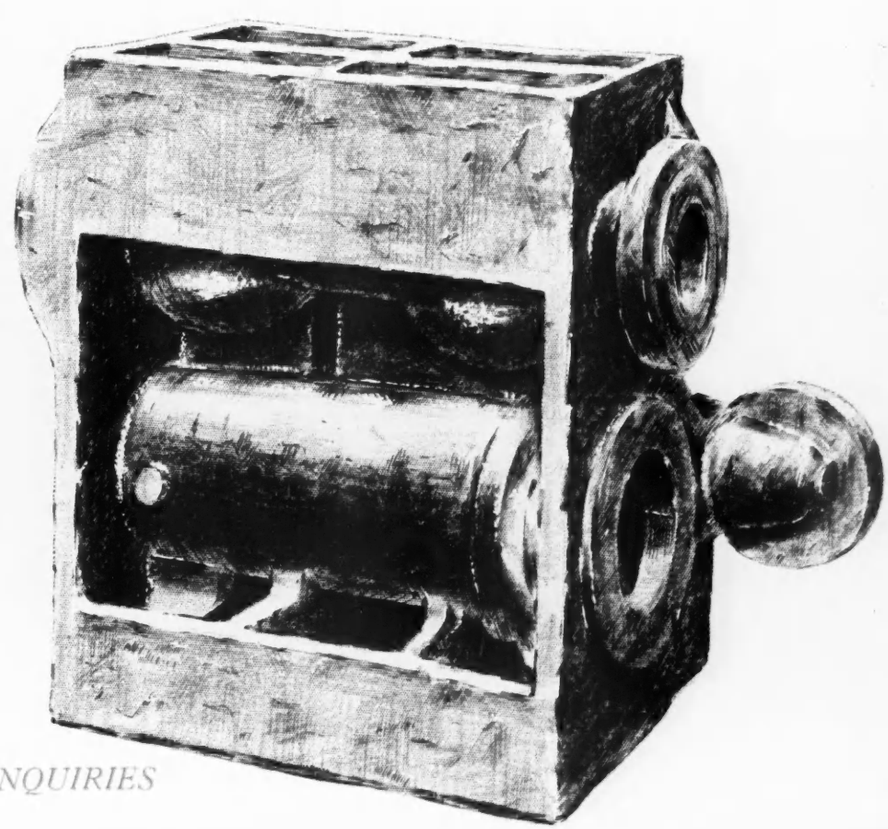

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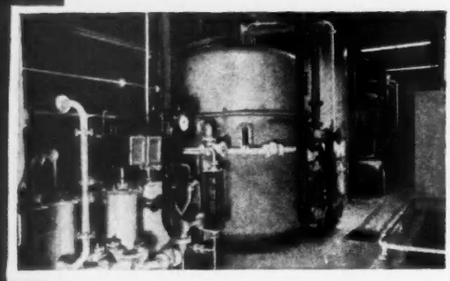

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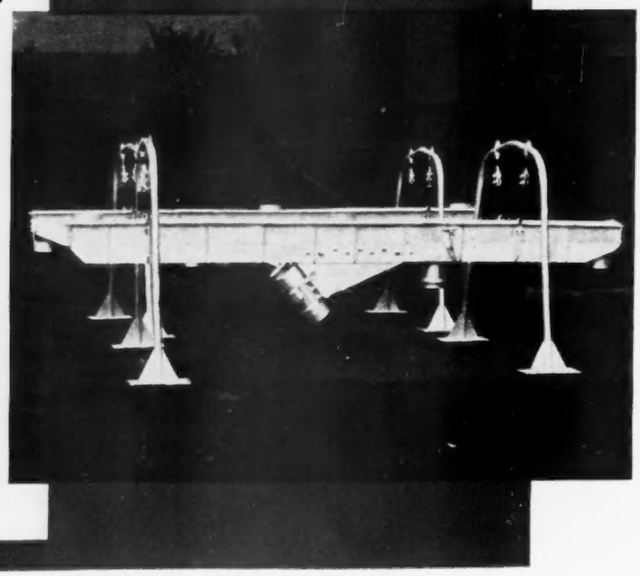

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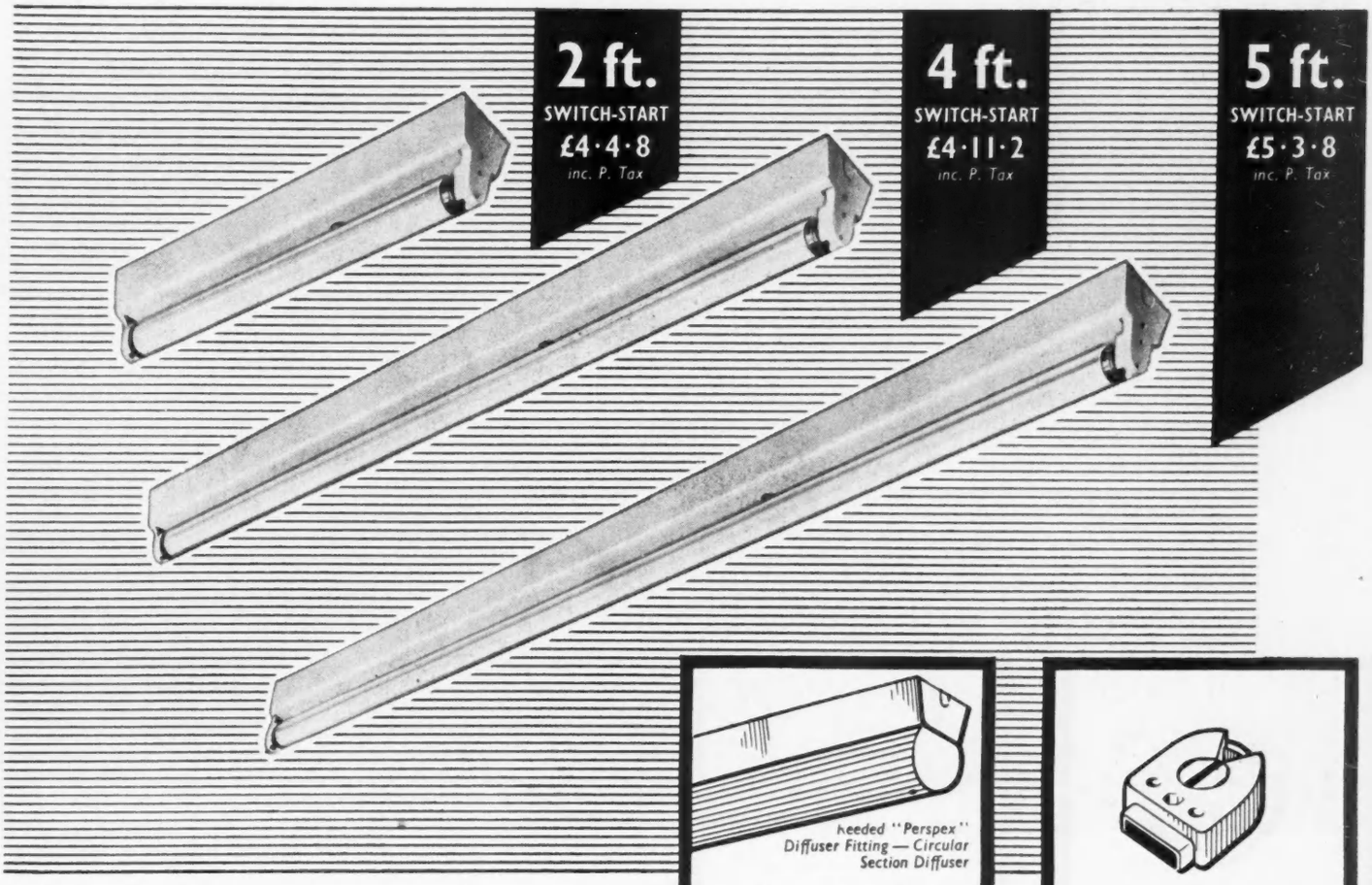

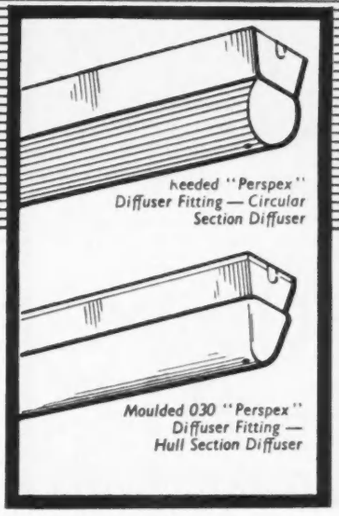
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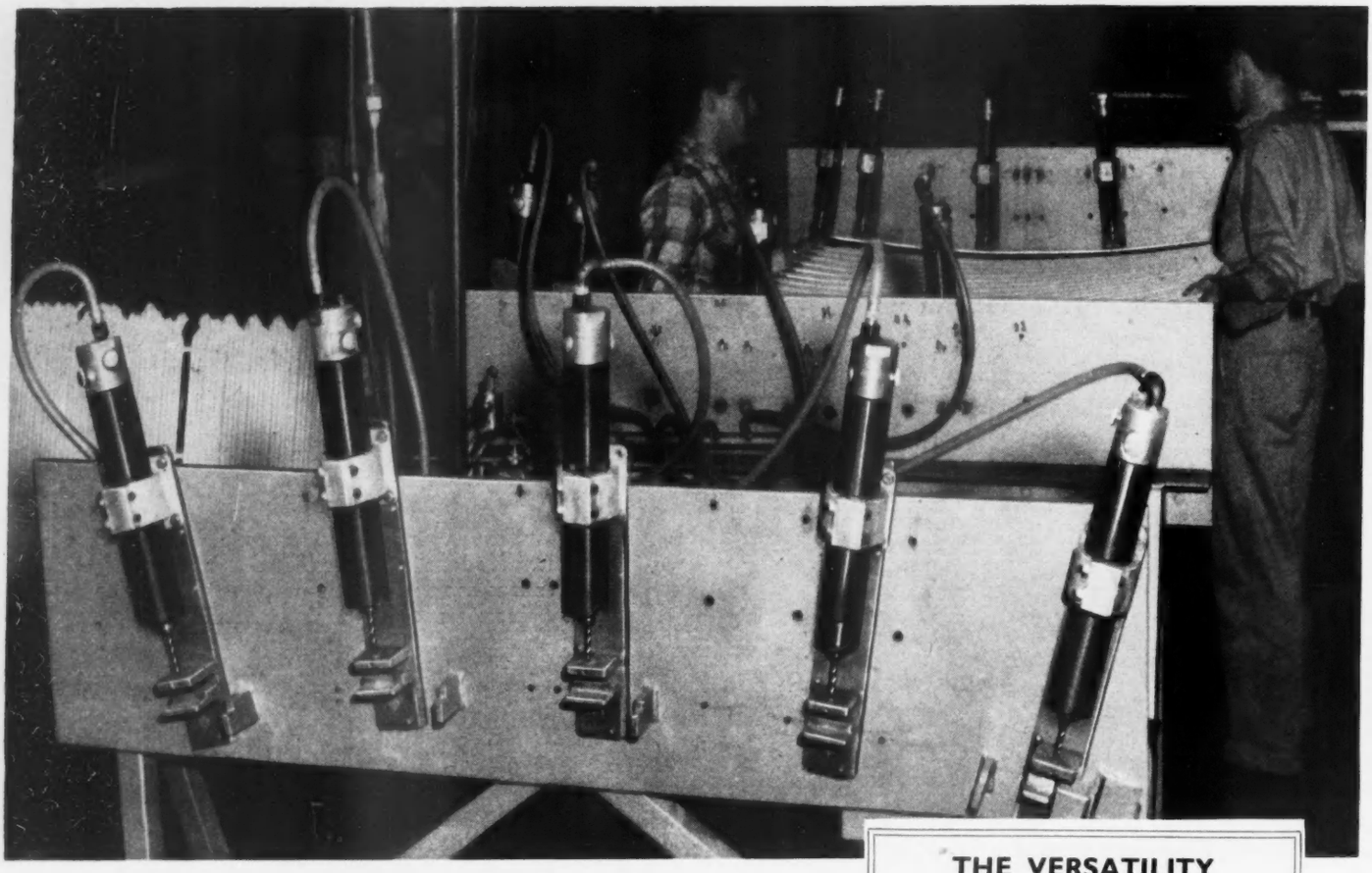

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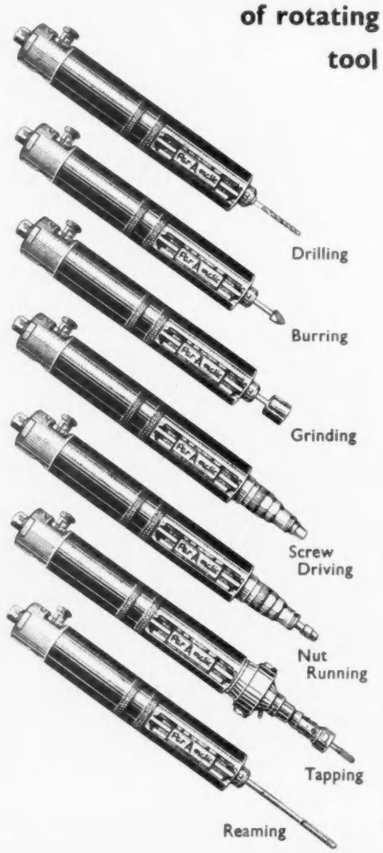

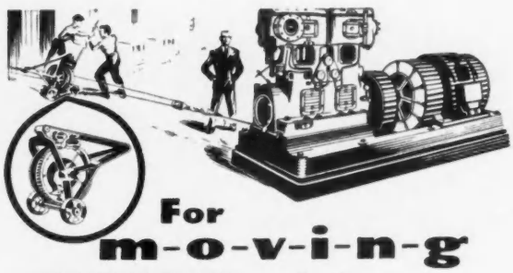

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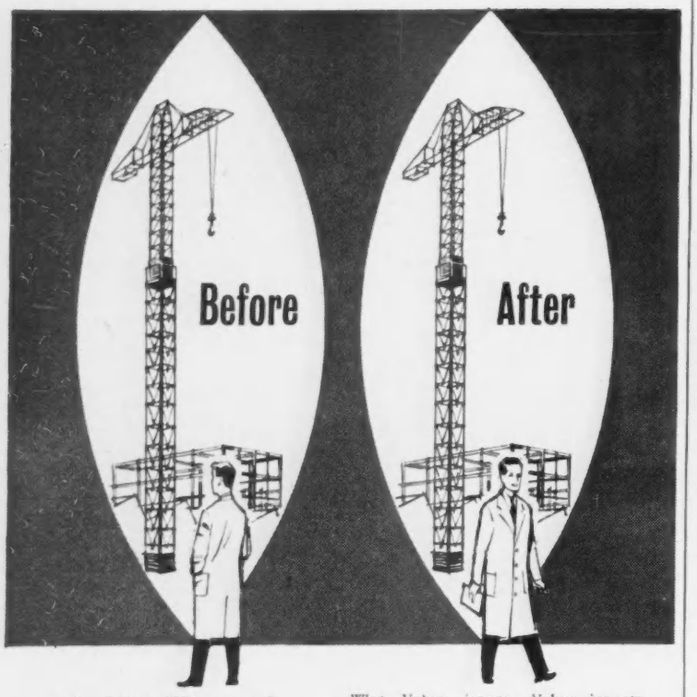

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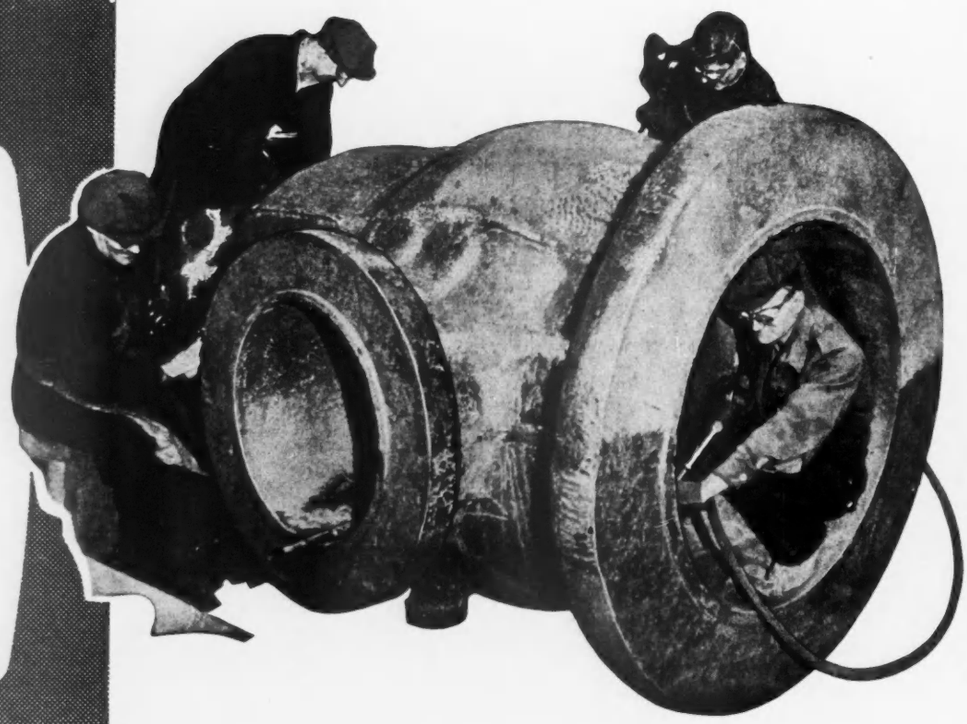

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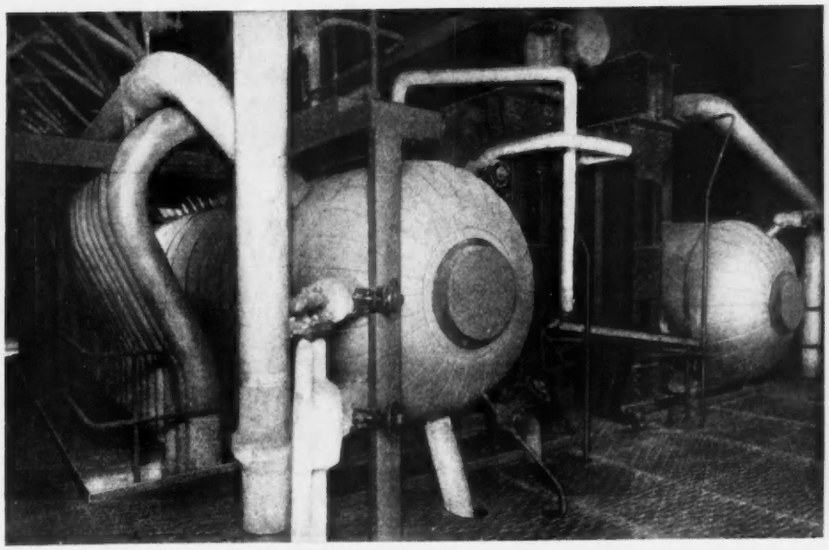
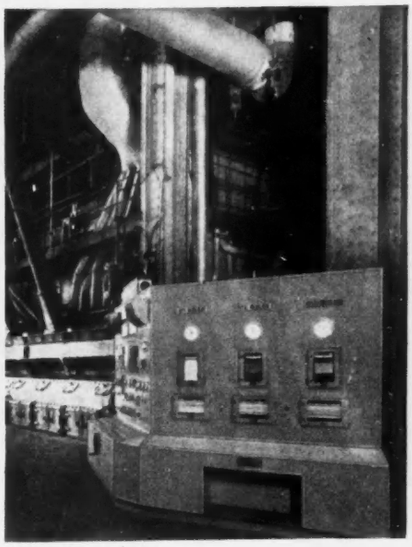


View at Steam Drum level.



View at Firing Floor level.

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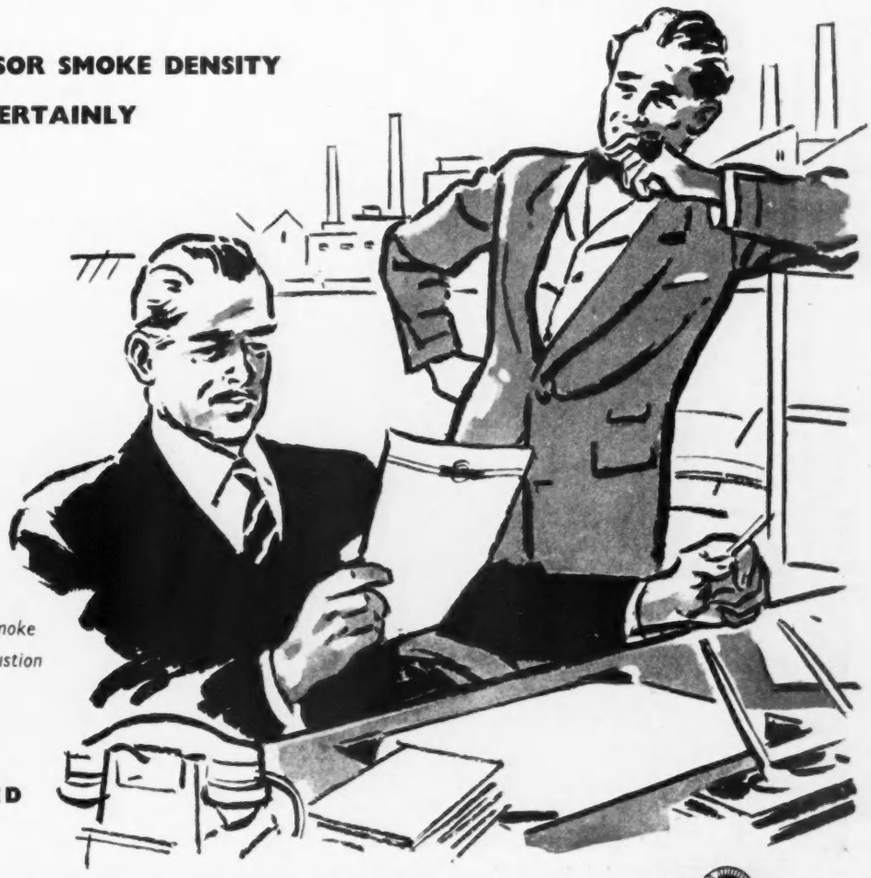

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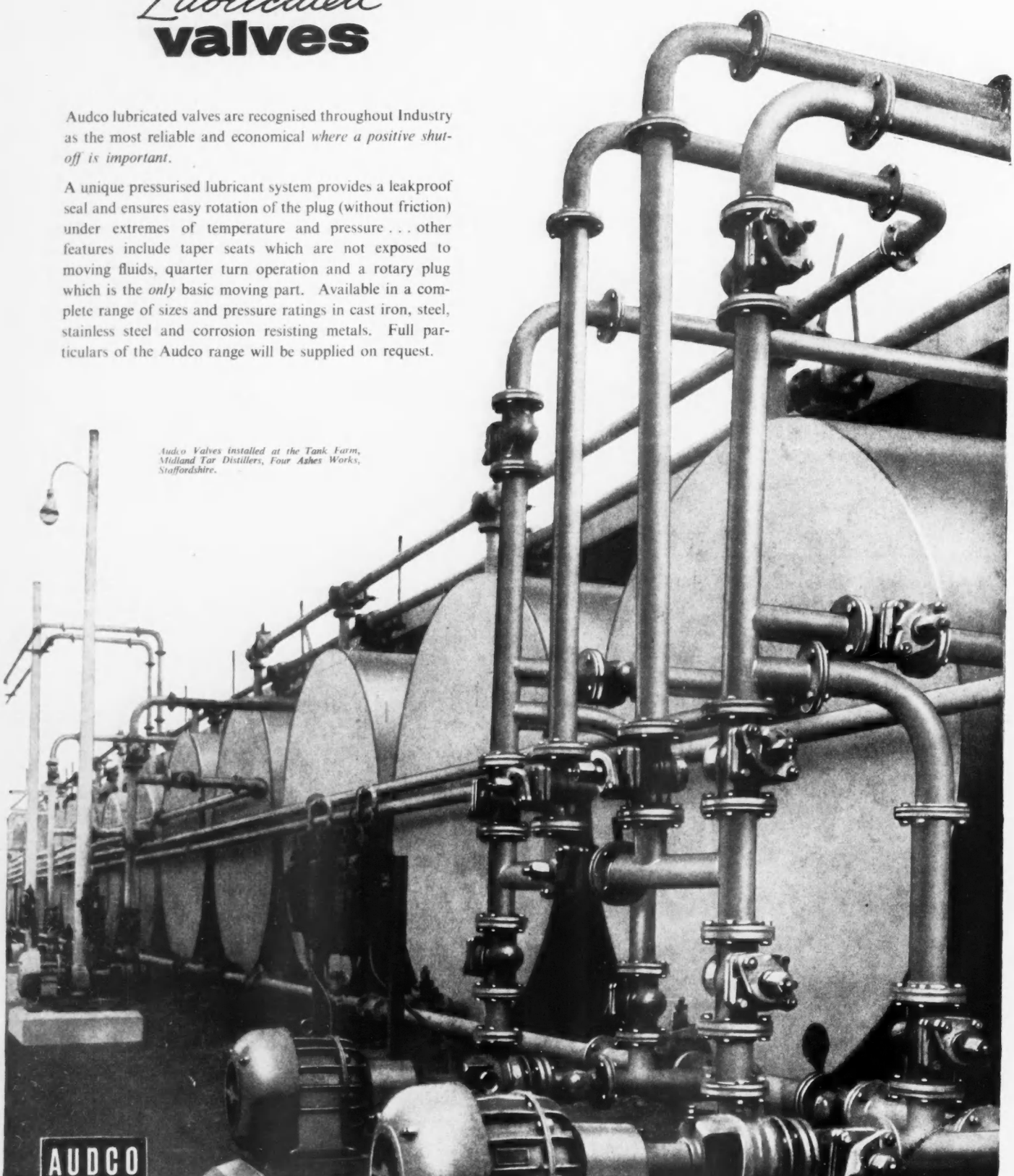
Lubricated **valves**

FOR A POSITIVE SHUT OFF

Audco lubricated valves are recognised throughout Industry as the most reliable and economical *where a positive shut-off is important.*

A unique pressurised lubricant system provides a leakproof seal and ensures easy rotation of the plug (without friction) under extremes of temperature and pressure . . . other features include taper seats which are not exposed to moving fluids, quarter turn operation and a rotary plug which is the *only* basic moving part. Available in a complete range of sizes and pressure ratings in cast iron, steel, stainless steel and corrosion resisting metals. Full particulars of the Audco range will be supplied on request.



Audco Valves installed at the Tank Farm, Midland Tar Distillers, Four Ashes Works, Staffordshire.

AUDCO VALVES

AUDLEY ENGINEERING CO. LTD., NEWPORT, SHROPSHIRE

PNEUTECHNIQUE

3 automatic compound controllers give greater flexibility, more accurate control

These Negretti & Zambra Compound Controllers fulfil the definite need in industry for flexible accurate automatic control. Operating on a clean, dry air supply at 20 p.s.i., they make automatic control of industrial processes easy, rapid, and convenient. In all three models the various units are standardised — so a model selected for a particular application can be readily adapted to others.

1 **BASIC CONTROLLER :** ***for use when manual control is not required.***

2 **CONTROLLER :** ***incorporating facilities for manual control internally.***

3 **CONTROLLER :** ***with auto/manual test facilities mounted externally on a sub-panel.***

Set-up procedure is extremely simple — a particular advantage where it is necessary to close down the plant periodically, as resumption of automatic control can be rapidly effected. Further advantages are :

- **NO INTERACTION BETWEEN TERMS,** ***enabling the controller to embrace wider plant characteristics than are possible with interacting controllers.***
- **IDEAL BASIC CONTROL RESPONSE** ***generated under all conditions.***
- **TRUE VALUES** ***of Proportional Band and Integral and Derivative Action Times are calibrated on the various units.***
- **OPTIMUM PLANT CONTROL** ***can be methodically and rapidly effected.***
- **TRULY CALIBRATED PLUG-IN UNITS** ***allow easy replacement without re-setting and facilitate servicing.***
- **EASILY CONVERTIBLE** — ***thus a two-term controller may be used with either Derivative or Integral Unit, and three-term controller with both units.***
- **SELF-CONTAINED UNITS,** ***compact and self-purging. FORCE-BALANCE PRINCIPLE of operation involves no levers and friction losses, the diaphragm assemblies giving high sensitivity.***

• • •

We will be pleased to send you a copy of our fully illustrated booklet No. R 35/2 on your request.

NEGRETTI & ZAMBRA

THE NAME THAT MEANS PRECISION ALL OVER THE WORLD

Agents or subsidiaries in all major countries

Factories at Barnsbury, London, N.1 · Aylesbury, Bucks, Chobham, Surrey
Head Office: 122 Regent Street, London, W.1
Telephone: REGent 3406

CLASSIFIED ADVERTISEMENTS

AGENCIES · DIRECTORS · PARTNERSHIPS · SITUATIONS VACANT · EDUCATIONAL PATENTS · BUSINESS OPPORTUNITIES · MISCELLANEOUS · PUBLIC APPOINTMENTS BUSINESSES and PREMISES · TENDERS

Lineage Rate. 4/- per line of approximately 6 words. Minimum 16/-

Inch Rate. 48/- per single column inch and *pro rata*. 12 lines to 1 inch.

There are reduced rates (*i.e.*, not on a *pro rata* basis) for advertisements of ¼-page (12 column inches) and upwards, e.g., ¼-page £25 10s. ½-page £48. Full page £90.

AUCTION SALES · FOR HIRE · MACHINERY, etc., WANTED · SITUATIONS WANTED DRAWING AND DESIGN SERVICES · FOR SALE · SUB-CONTRACTING

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Series Discounts. For advertisements 1 inch and upwards. 6 insertions 5%. 13 insertions 10%. 26 insertions 15%.

Run-on and Semi-Displayed Styles. Both these styles are available for single column width advertisements of any depth up to 12 inches.

Displayed and Illustrated Styles. The minimum size for a Displayed advertisement is 3 inches single column, for an illustrated advertisement it is a ¼-page (12 column inches). Thereafter the sizes for both progress in steps 3 inches deep across 1, 2, 3 or 4 columns.

Use of Box Number. 2/- which includes forwarding of replies.

Copy Dates. "Run-on" and "Semi-displayed" advertisements by noon Tuesday for publication on Friday same week. "Displayed" and "Illustrated" advertisements by noon Friday for publication on following Friday. All advertisements three days earlier if proofs are required.

***Advertisements for publication should be addressed to*—Classified Advertisement Dept., "The Engineer", 28 Essex Street, Strand, London, W.C.2.**

Urgent advertisements may be telephoned to CENtral 6565.

PUBLIC APPOINTMENTS

NEWCASTLE UPON TYNE EDUCATION COMMITTEE

RUTHERFORD COLLEGE OF TECHNOLOGY

(SELECTED FOR DEVELOPMENT INTO A COLLEGE OF ADVANCED TECHNOLOGY)

APPOINTMENTS

Applications are invited for the following posts :—

(i) HEAD OF DEPARTMENT OF MECHANICAL AND CIVIL ENGINEERING (GRADE V). Salary £1900 by £50 to £2050. Applicants, who should be mechanical engineers, should have a good or higher University Degree, be professionally qualified and have had good industrial, research and preferably, teaching experience.

(ii) SENIOR LECTURER IN MECHANICAL ENGINEERING, for work in connection with Higher National Certificate, Higher National Diploma, Dip. Tech. and Degree courses. Applicants should hold a good Honours or Higher Degree, be Corporate Members of a professional institution, have had good industrial and/or research and, preferably, teaching experience ; and be able to offer two or more of the following :—Applied Thermodynamics and Heat Transfer, Theory of Machines, Mechanics of Fluids and Hydraulics, Machine Design.

(iii) LECTURER IN CIVIL ENGINEERING, for Higher National Certificate and Higher National Diploma courses, including Structural Engineering. Applicants should hold a good Degree in Civil Engineering, have had at least 3 years' experience in the design and construction of civil engineering works and, preferably, some teaching experience.

(iv) LECTURER IN MECHANICAL ENGINEERING, for Higher National Certificate and Higher National Diploma courses. Applicants should hold a good Degree, have had industrial and, preferably, teaching experience.

(v) LECTURER IN METALLURGY, capable of teaching up to L.I.M. standard in Mechanical and Thermal Treatment, and in Production of Iron and Steel. Applicants should be graduates with practical experience, preferably in the steel-making industry, and have spent some time in teaching.

Salary scales : Senior Lecturer, £1350 by £50 to £1550 ; Lecturer, £1200 by £30 to £1350.

Application forms (returnable within fourteen days) and further particulars may be obtained from the Principal, Rutherford College of Technology, Bath Lane, Newcastle upon Tyne, 1. E9273

UNIVERSITY OF LONDON KING'S COLLEGE

RESEARCH STUDENTSHIPS

University of London King's College offers the following RESEARCH STUDENTSHIPS, made available by Joseph Lucas, Ltd., and tenable in the College for one year with possible renewal for a second year.

(a) One of £800 a year for research into the initiation of explosions in gases, vapours and powder clouds.

(b) One of £500 a year for research into the mixing of powdered materials.

The character of the researches is such as should lead to a Higher Degree. Applicants for (a) should have a good Honours Degree in Mechanical or Electrical Engineering or Physics, and preferably some research experience. Applicants for (b) should have a good Honours Degree in some branch of Engineering, Physics or Chemistry.

Particulars and application forms from the Registrar, King's College, London, Strand, W.C.2, whom completed forms must reach by December 17th. E9261

KENT EDUCATION COMMITTEE

NORTH-WEST KENT COLLEGE OF TECHNOLOGY

ASSISTANT (GRADE B)

ASSISTANT (Grade B) required to teach Engineering Science in National Certificate courses and other subjects, according to qualifications. Large new, well-equipped laboratories just opened. Salary, £650 by £25 to £1025, with additions and starting point dependent upon experience and qualifications.

Further particulars and forms of application are obtainable from the Principal at the College, Miskin Road, Dartford. E9233

PUBLIC APPOINTMENTS

ROYAL AIRCRAFT ESTABLISHMENT TECHNICAL COLLEGE

FARNBOROUGH, HANTS

LECTURERS

Applications are invited for the following vacancies in the above College :—

Post 1 : SENIOR LECTURER IN AIRCRAFT STRUCTURES.

Post 2 : LECTURER IN MECHANICAL ENGINEERING.

Post 3 : ASSISTANT LECTURER (B) in ENGINEERING.

University Degree or equivalent, and preferably some industrial and/or teaching experience.

Candidates for Post 1 should be capable of accepting responsibility for teaching the subject for final B.Sc. (Eng.), Diploma in Technology, and A.F.R.Ae.S. The Dip. Tech. course includes the subject as one in which students may specialise and do their research project.

For Posts 2 and 3 ability to teach general Mechanical Engineering subjects to H.N.C. standard and possibly some Dip. Tech. work, required. Candidate for either post may be invited to act as O/C, College Experimental Flight Testing Training with a special additional allowance.

Facilities for further study and/or research may be available. Duties to commence as soon as possible.

Burnham Scale for Technical Colleges (subject to Teachers' Superannuation Acts) : Senior Lecturer, £1350 by £50 to £1550 ; Lecturer, £1200 by £30 to £1350 ; Grade B, £650 by £25 to £1025. Commencing salary in accordance with experience.

Application forms from Principal of College for return within 14 days. E9242

COUNTY BOROUGH OF WEST HAM EDUCATION COMMITTEE

WEST HAM COLLEGE OF TECHNOLOGY

ROMFORD ROAD, STRATFORD, E.15

Principal : E. A. RUDGE, M.Sc., Ph.D., A.M.I.Chem.E.

LECTURER IN CIVIL ENGINEERING

Required : LECTURER IN CIVIL ENGINEERING, to teach to University Degree and H.N.C. Standard. Candidates should be Graduates with industrial and teaching experience.

Salary : £1200 by £30 to £1350, plus London Allowance.

Application forms and particulars from the Principal.

R. OPENSHAW,
Chief Education Officer.

E9256

UNIVERSITY OF SHEFFIELD

SENIOR LECTURER IN MECHANICAL ENGINEERING

Applications are invited for a post of SENIOR LECTURER IN MECHANICAL ENGINEERING, to begin duties on 1st April, 1959, or as soon as possible thereafter. Initial salary on the scale £1650 by £75 to £2025, according to qualifications and experience, with F.S.S.U. provision and family allowance.

Further particulars should be obtained from the Registrar to whom applications (two copies, one only from overseas candidates) should be sent by 31st January, 1959. E9239

UNIVERSITY OF LONDON KING'S COLLEGE

RESEARCH STUDENTSHIP

University of London King's College offers a RESEARCH STUDENTSHIP, made available by Usines Emile Henricot, S.A., and tenable for one year with possible renewal for a second year. The value will be £500 per annum. The Studentship is for research into various aspects of the mechanical behaviour of ball mills ; the character of the research is such that it should lead to a Higher Degree. Applicants should have a good Honours Degree in some branch of Engineering.

Particulars and application forms from the Registrar, King's College, London, Strand, W.C.2, whom completed forms must reach by December 17th. E9262

PUBLIC APPOINTMENTS

ATOMIC WEAPONS RESEARCH ESTABLISHMENT

ALDERMASTON, BERKS

ENGINEER (SENIOR GRADE)

ENGINEER (SENIOR GRADE) required by the Atomic Weapons Research Establishment, Aldermaston, Berks. To be responsible for the installation of nuclear research facilities associated with the operation of a 5MW Light Water Moderated Research Reactor and the construction and assembly of experimental rigs including the necessary engineering services. To assist with the supervision of construction and the commissioning of the reactor, and design and installation of future modifications.

A recognised engineering apprenticeship and Corporate Membership of the Institution of Mechanical or Electrical Engineers required. An Honours Degree would be an advantage. Candidates must have had previous experience on commissioning and operation of research reactors and be familiar with the engineering problems associated with reactor experimental rigs and facilities and their maintenance.

Salary : £1790–£2080.

Contributory Superannuation scheme. A modern house with garage or alternatively substantial assistance with house purchase will become available for married officers living beyond daily travelling distance.

Postcards for application forms to the Senior Recruitment Officer at the above address. Please quote Ref. 2084/25. E9229

USK RIVER BOARD

ASSISTANT ENGINEER

Applications are invited for the position of ASSISTANT ENGINEER on scale A.P.T. I (£575–£725), with a car allowance on the Essential User Scale for a car not exceeding 1199 cc., and subject to the National Scheme of Conditions of Service. Applicants should have completed the period of practical training required by the Professional Institutions and preference will be given to applicants who have taken part of the examinations of the Institution of Civil Engineers, and who have had experience in River Board or land drainage work.

Applications should state the age, technical training and previous experience of the applicant and copies of two recent testimonials should be attached. Applications should be addressed to the undersigned, to be received not later than the first post on Monday, the 8th December.

The appointment will be a designated post for the purposes of the Superannuation Acts and will be subject to a medical examination. In the case of a married man, assistance may be granted towards approved removal expenses. The appointment will be terminable by one month's notice on either side.

G. McLEOD, M.I.C.E.,
Engineer to the Board.

"The Croft,"
Caerleon, Mon.
17th November, 1958. E9225

COUNTY BOROUGH OF BRIGHTON

WATER DEPARTMENT

MECHANICAL SUPERINTENDENT

Applications are invited for the post of MECHANICAL SUPERINTENDENT. Salary within the Grade A.P.T. III (£845–£1025).

Applicants must have had a sound workshop training, with experience in maintenance and repair of electrical and steam pumping plant, sterilisation and electro-mechanical control equipment.

The appointment is subject to the provisions of the Local Government Superannuation Act and the passing of a medical examination, and is terminable by one month's notice on either side.

Application forms from Waterworks Engineer, 12, Bond Street, Brighton, 1, to be returned endorsed "Mechanical Superintendent," by 15th December, 1958. Canvassing will disqualify.

W. O. DODD,
Town Clerk.

Town Hall,
Brighton.
November, 1958. E9274

PUBLIC APPOINTMENTS

UPPER WITHAM INTERNAL DRAINAGE BOARD

APPOINTMENT OF TEMPORARY ASSISTANTS

Applications are invited for the following appointments for a minimum period of two years, successful candidates to be engaged on the preparation and supervision of land drainage pumping schemes.

(a) DESIGN ASSISTANT, salary within Special Grade (£750–£1030) according to qualifications. Candidates should preferably have had experience of land drainage work. An allowance will be paid for the use of a car not exceeding 10 h.p. or 1119 c.c.

(b) DRAUGHTSMAN SURVEYOR, salary in accordance with A.P.T. Grade I (£575–£725) commencing salary to be fixed according to experience.

Applications stating age, qualifications, experience, particulars of present employment and when the applicant would be free to take up employment, accompanied by copies of testimonials, should be made to the undersigned not later than Saturday 13th December, 1958.

J. BARNATT, A.M.I.C.E., A.M.I.W.E.,
Engineer to the Board.

20, Orchard Street,
Lincoln. E9181

CIVIL SERVICE COMMISSION

MINISTRY OF TRANSPORT AND CIVIL AVIATION

CIVIL ENGINEERS

Ministry of Transport and Civil Aviation : CIVIL ENGINEERS.

Pensionable posts for men and women aged 25 and under 35 on 1st January, 1958 ; extension for regular Forces service, Overseas Civil Service, established Civil Service, and temporary Government service as Civil Engineer. Candidates must have achieved Corporate Membership of Institution of Civil Engineers or passed examinations necessary for attaining Corporate Membership.

Experience in road and bridge construction essential ; knowledge of Highways Authorities' procedure desirable. Men's starting salary from £755 to £1085. Maximum (London) £1250. Promotion prospects.

Write, Civil Service Commission, 30, Old Burlington Street, London, W.1, for application form, quoting S64/58. E9255

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

ENGINEERING RESEARCH LABORATORY, EAST KILBRIDE, GLASGOW

SCIENTIFIC OFFICERS OR SENIOR SCIENTIFIC OFFICERS

D.S.I.R. requires Engineers as SCIENTIFIC OFFICERS or SENIOR SCIENTIFIC OFFICERS at the Mechanical Engineering Research Laboratory, East Kilbride, Glasgow, for research on (Ref. C 759/8A) Stress Distribution in Engineering Components Affected by Stress Raisers, such as cracks ; good mathematical background essential ; (Ref. C760/8A) Oil Hydraulic Machinery, including control and relief valves, Hydraulic Pumps, Motors and Power Transmissions ; ability in theoretical analysis desirable ; (Ref. C761/8A) Application of Servo Control to Machine Tools ; knowledge of servo-theory and experience of electrical servo design and development essential ; knowledge of hydraulic servo techniques or machine tool design an advantage.

Qualifications : 1st or 2nd Class Honours Degree in Mechanical Engineering or equivalent. Salary ranges : S.O. £595–£1050, allowance for National Service and post-graduate experience. S.S.O. (minimum of 3 years p.g.e.), £1130–£1330. Houses available in New Town for married staff.

Forms from M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting the appropriate Ref. No. Closing date, 19th December, 1958. E9254

PUBLIC APPOINTMENTS

UNITED KINGDOM ATOMIC ENERGY AUTHORITY, INDUSTRIAL GROUP

RISLEY, WARRINGTON, LANCASHIRE

ENGINEER AND PHYSICIST

ENGINEER AND PHYSICIST are required in the Industrial Power Branch of the United Kingdom Atomic Energy Authority, Industrial Group, at its Headquarters, Risley, Warrington, Lancashire, to be responsible for development of safe design of nuclear power reactors for industrial use, co-ordination of the content of technical reports prepared for licensing the reactors, and implementation of design recommendations.

A recognised engineering apprenticeship and corporate membership of a senior engineering institution for the Engineer appointment, or possession of an honours degree, or equivalent, in physics for the Physicist appointment are essential. Experience in the duties outlined is desirable but not essential, as training will be given where necessary.

Salary between £815 (at age 25) and £1740 according to qualifications and experience.

Contributory Superannuation. Staff housing scheme.

Send postcard for application form, quoting reference 2742/J.1 to Recruitment Officer at above address.

Closing Date : 8th December, 1958.

E9228

CENTRAL ELECTRICITY GENERATING BOARD

SOUTH WALES DIVISION

MAINTENANCE ENGINEER (MECHANICAL)

VACANCY No.: 127/E/58

Applications invited for superannuable N.J.B. appointment of MAINTENANCE ENGINEER (MECHANICAL) at Uskmouth Power Station, near Newport, Mon.

Salary : K.5, £1325–£1415 per annum.

Applicants should have had wide experience in power station mechanical maintenance, and preferably be Corporate Members of the Institution of Mechanical Engineers, or hold equivalent qualifications.

Special application forms obtainable from Secretary, South Wales Division, Central Electricity Generating Board, Twyn-y-fedwen Road, Gabalfa, Cardiff, to be returned by 12th December, 1958.

E9253

PUBLIC APPOINTMENTS

LONDON ELECTRICITY BOARD

DRAWING OFFICE JUNIOR

Applications are invited for the above position under the supervision of a Structural Engineer in the Construction Branch of the Chief Engineer's Department in central London (near Waterloo).

Applicants should be interested in structural engineering as a profession, and should preferably possess the General Certificate of Education with passes at Ordinary Level in English, Elementary Mathematics, one or two approved science subjects, &c.

The commencing salary, within the General Clerical Grade of the National Joint Council Agreement (Administrative and Clerical Grades), i.e. £255 per annum at age 16, rising thereafter within scale.

Application forms obtainable from Personnel Officer, 46, New Broad Street, London, E.C.2. Please quote ref. PER/2220/EE. E9234

NEW SOUTH WALES GOVERNMENT OFFICES

ENGINEER

ENGINEER, with Degree or equivalent professional qualifications to A.M.I.Mech.E. standard, having at least 5 years' experience in steam turbine design and/or operation after having completed recognised apprenticeship. Experience in testing turbine plant and materials is also desirable. Commencing salary up to £1455 p.a., according to qualifications and experience.

Duties will involve general supervision of contracts and visits to contractors' works as required.

Applications, stating age, education, qualifications and experience in chronological order, should be forwarded to the Agent-General for New South Wales, 56, Strand, London, W.C.2, endorsed " Engineering Appointment." Original testimonials should not be included. E9246

STEPNEY METROPOLITAN BOROUGH COUNCIL

MAINTENANCE ENGINEER

Stepney M.B.C. require MAINTENANCE ENGINEER for central heating and domestic hot water supply installations, laundries, &c., at housing estates ; extensive knowledge and experience of appropriate engineering practice required. £715–£775, plus rent-free accommodation.—Forms and other particulars from Town Clerk, 227, Commercial Road, E.1. Closing date 22nd December, 1958. E9269

PUBLIC APPOINTMENTS

LIVERPOOL REGIONAL HOSPITAL BOARD

ASSISTANT ENGINEER

ASSISTANT ENGINEER (Mechanical) required on the staff of the Regional Engineer.

Applicants should be at least G.I.Mech.E. or A.M.I.H. and V.E., and have passed the appropriate Institution examination and able to conduct site surveys. Experience in the preparation of drawings and specifications for engineering equipment and heating and ventilating schemes is essential.

Salary scale : £700–£1015 per annum.

Starting salary dependent on age and previous relevant practical experience.

Applications, stating age, qualifications, experience, present and previous posts, with names and addresses of three referees (2 technical), to reach me at 55, Castle Street, Liverpool, 2, by 5th December, 1958.

VINCENT COLLINGE,
E9204 Secretary to the Board.

COLNE VALLEY WATER COMPANY

FOREMAN INSTRUMENT MECHANIC

FOREMAN INSTRUMENT MECHANIC required.

Preference will be given to applicants having wide experience in the repair and maintenance of all kinds of Waterworks instruments and holding a recognised qualification.

Salary : £600 per annum, rising (subject to satisfactory service) to £780 per annum.

Applications, giving details of past experience, should reach the Chief Engineer, The Colne Valley Water Company, Aldenham Road, Watford, Herts, by Monday, 8th December, 1958. E9236

BARNSLEY CORPORATION WATER DEPARTMENT

ASSISTANT ENGINEER

ASSISTANT ENGINEER, A.P.T. Grade IV.

Full particulars from Waterworks Engineer and Manager, Town Hall, Barnsley, Yorkshire. E9258

TENDERS

KINGDOM OF THAILAND

ROYAL IRRIGATION DEPARTMENT

BANGKOK, THAILAND

The Royal Irrigation Department of the Kingdom of Thailand requests sealed written bids for FURNISHING and DELIVERING F.O.B. contractor's shipping point for the Bhumiphol Dam and Power Plant, Yanhee Multipurpose Project, Kingdom of Thailand, in accordance with the Contract Documents, Invitation for Bids, No. YS-1-1, the following equipment :

TRACTOR UNITS ; FLATBED, VAN, BOTTOM-DUMP, and REFRIGERATOR SEMITRAILERS ; WRECKER VAN, FLATBED, and UTILITY TRUCKS ; FORK LIFT TRUCKS ; MARINE DIESEL ENGINES ; and ROAD VEHICLE WEIGHING SCALE.

Bids will be opened at 10.00 a.m., 5 February, 1959. Copies of the Contract Documents, Invitation for Bids, No. YS-1-1, may be obtained by qualified Bidders on written request on Bidder's letterhead, addressed to Royal Irrigation Department, Attention : Thai Liaison Engineer, c/o Engineering Consultants, Inc., 1940 West Mississippi Avenue, Denver 23, Colorado, U.S.A. Each request must be accompanied by a cheque or money order, payable to the Royal Irrigation Department, in the amount of U.S. $10.00 for each copy of the Contract Documents requested.

M. L. XUJATI KAMBHU,
Director General,
E9268 Royal Irrigation Department.

EDUCATIONAL

TECHNICAL HOME STUDY COURSES

For A.M.I.Mech.E., A.M.I.Chem.E., A.M.I.M.I., A.F.R.Ae.S., C.& G., &c.

OVER 50 FIRST PLACES and more than 2000 Passes have been secured by T.I.G.B. Students at Professional Engineering Examinations. We have a wide range of exclusive Home Study Courses in all branches of Engineering—Mechanical, Electrical, Aeronautical, Automobile, Chemical, Gas, Radio, and Television, Draughtsmanship, &c. Textbooks, blueprints, &c., are provided and, if desired, fees may be paid by moderate instalments.—Write (stating subject of interest) for copy of 110-page Prospectus FREE and without obligation.

THE TECHNOLOGICAL INSTITUTE OF GREAT BRITAIN
(Dept. 76),
29, WRIGHT'S LANE, LONDON, W.8.
E102 E

A.M.I.MECH.E., B.Sc., City and Guilds, &c. Guarantee Postal Courses for all Exams., and Technical Divisions from Elementary to Degree standard including Automation Techniques. Approximately 95 per cent. successes. 148-page prospectus free on request.—B.I.E.T. (Dept. 22), 29, Wright's Lane, London, W.8. E114 E

EDUCATIONAL

UNIVERSITY OF LONDON

A lecture entitled " Motorways " will be delivered by Dr. W. H. Glanville (Director of Road Research, Department of Scientific and Industrial Research) at 5.30 p.m. on 5 December at the University of London, Senate House, W.C.1. Admission Free, without Ticket.

JAMES HENDERSON,
E9231 E Academic Registrar.

SITUATIONS VACANT

APPLICANTS ARE ADVISED TO SEND COPIES, NOT ORIGINALS, OF THEIR TESTIMONIALS UNLESS OTHERWISE REQUESTED.

A DESIGNER/DRAUGHTSMAN (MECHANICAL) is required by MICHELIN TYRE COMPANY, LTD., for interesting project work at their Stoke-on-Trent factory.

Applicants should have served a sound engineering apprenticeship in this country, possess H.N.C. (with Heat Engines, Applied Thermodynamics, or Steam Engineering endorsement preferred) and have had experience of problems involving steam and industrial hydraulic applications.

The appointment is permanent and pensionable. A 5-day 40-hour week and 3 weeks' annual holiday in force.

Housing assistance given if necessary. Tax free allowance of £4 a week for married men pending removal. Company pays removal charges.

Please write to MICHELIN TYRE COMPANY, LTD. (SPA Dept), STOKE-ON-TRENT, STAFFS, quoting Reference B/305/TE.

E9209 A

AN EXPERIENCED SALES REPRESENTATIVE, preferably with bias towards mechanical engineering and fabricated steelwork, is required by a well-established company in the South of England, with ferrous and non-ferrous foundries, constructional and fabricated steel and mechanical engineering divisions. Must be modern car owner and resident in, or adjacent to, North London. Payment by salary, expenses and bonus. Compulsory pension scheme in operation. It is visualised that the area assigned will be Berkshire and Buckinghamshire, also parts of North London, Middlesex and Surrey, and live contacts in this area would be an advantage. —Please reply with full details of age and career to date to Sales Manager, BOX No. E9275, " The Engineer." A

AN ORGANISATION IN THE EAST MIDLANDS HAS A VACANCY for an ENGINEER with specialist experience of cutting tool development and investigations into machining problems. The successful applicant will be responsible for practical tests and studies of production difficulties. Commencing salary not less than £850 p.a.—Please send details of career and qualifications. to BOX No. E9169, " The Engineer." A

DESIGNER-DRAUGHTSMAN

An experienced Designer-Draughtsman is required to work in an expanding design section specialising in materials handling equipment. Applicants should preferably have had experience in the design of one or more of the following groups of equipment :—Conveyors, screens, gantries, hoppers, chutes, special-purpose heavy vehicles ; however, candidates with suitable mechanical and structural design experience of a similar type will be considered. Academic qualifications required are Higher National Certificate in Mechanical Engineering, or equivalent. A good salary will be paid, plus company productivity bonus and contributory pension scheme. Good opportunity for promotion for man with the right experience and capable of leading a small design team.

Candidates should apply in their own handwriting, giving brief details of their experience to;
QUALTER, HALL AND CO., LTD.,
P.O. Box 8,
Railway Foundry,
Barnsley.

E2200 A

DESIGN/DRAUGHTSMAN

required by rapidly expanding engineering company for new factory to be erected in East Anglia. The duties and responsibilities require a knowledge of plant layout, mechanical handling, automatic feed mechanisms, coupled with general factory services. Previous experience in these fields essential and require qualifications to H.N.C. level. Knowledge of production engineering or time study would be advantageous. The post initially tenable in Essex and later in East Anglia.

The company offer attractive working conditions and operate a part-contributory pension and life assurance scheme, and a salary commensurate with age, experience and qualifications.

Applications, giving full details of career should be made to Chief Engineer, Roneo, Ltd. Romford, Essex.

E2202 A

DRAUGHTSMAN experienced in the detailing and design of structural steelwork required by Company in the South of England. Only those with good experience of this type of work should apply. State salary required.—Reply to BOX No. E9213, " The Engineer." A

Classified Advts. continued on page 118

A.E.R.E. HARWELL

REF. 1275/25

PROFESSIONAL ENGINEERS (A.M.I.Mech.E. normal minimum) are required, to be responsible to a Senior Engineer for preparing basic specifications for use in the design and manufacture of in-reactor experimental rigs. This work involves close liaison with scientists (*a*) to provide equipment able to meet stringent requirements and (*b*) in the preparation of preliminary designs involving heat transfer, fluid flow and nuclear calculations. Engineering design experience essential ; aptitude for technical writing and calculating desirable.

Salary : £1300–£1740 (or £815–£1270 for younger engineers).

STANDARDS ENGINEER REF. 1274/25

A PROFESSIONAL ENGINEER is required to investigate designs for possible standardisation and to prepare specifications and codes of practice in relation to engineering materials and manufacturing processes. This will involve liaison with scientists and design engineers and supervision of standards office staff circularising appropriate technical data. Relevant experience and familiarity with B.S.S. and codes of practice essential ; knowledge of special materials used in the Atomic Energy field desirable.

Salary : £1300–£1740 (Engineer II).

REACTOR ENGINEERING REF. 1262/25

PROFESSIONAL ENGINEERS (A.M.I.Mech.E. normal minimum) are required for design of alterations and additions to experimental reactors. This involves specifying plant/equipment for reactors and building services and close collaboration with operations and design sections. Experience required (*a*) for all posts—in mechanical design ; (*b*) for one post—in site engineering on erection of mechanical equipment : (*c*) for one post—pressure vessel design, manufacture and inspection.

Salary between £815 and £1740 depending on age, qualifications and experience (Engineer II or III).

Please send a postcard quoting appropriate reference to the Group Recruitment Officer, U.K.A.E.A., Atomic Energy Research Establishment, Harwell, Berks, for details.

E9257

SITUATIONS VACANT

DRAUGHTSMAN—SECTION LEADER—required, fully conversant with air-conditioning, dust and fume extract plants, hot water and steam piping. Higher National Certificate or equivalent preferred. Progressive company, North-West Middlesex.—Write full details, BOX E547, L.P.E., Romano House, 399/401, Strand W.C.2. E9240 A

ENGINEERING INSURANCE. Applications are invited from Mechanical Engineers not over 35 years of age, who, having served an apprenticeship with Crane and Lift Makers, have a sound theoretical and practical knowledge of Cranes, Lifts, Lifting Machines and their maintenance, and are qualified to Higher National Certificate standard, for a vacancy as ENGINEER SURVEYOR in the West Country. The position is permanent, pensionable, with salary scale of £735, rising to £1060 per annum, plus expenses and allowances. Apply in own handwriting.—BOX No. E9189, "The Engineer." A

ENGINEERS FOR MIDDLE EAST

(a) Qualified Engineers, with 10 years' experience engineering, construction and operation of pipeline, pump stations and tank farms.

(b) Mechanical Engineer, with 5 years' experience engineering and construction of pipeline, pump stations and tank farms.

(c) Mechanical Engineers, with extensive experience construction of pipeline, pump stations and tank farms.

Submit curriculum vitæ, stating whether for (a), (b) or (c), to BOX No. 2101, c/o Charles Barker and Sons, Ltd., Gateway House, London, E.C.4.

E9243 A

ENGINEERS FOR SOUTH AMERICA

Qualified English-speaking MECHANICAL ENGINEERS required for important positions in a large steam power station in South America. Applicants should be corporate members of The Institution of Mechanical Engineers or hold a University engineering degree or Higher National Certificate. They must have at least five years' experience in a responsible position in a steam station of 50MW or larger.

The positions are interesting and permanent, and carry a generous starting salary up to £4,000 per annum depending on experience.

Full details should be given of age, education, qualifications and experience, and applications addressed to: Messrs. Macknesss and Shipley, Consulting Engineers, Parliament Mansions, Abbey Orchard Street, London, S.W.1. Reference 2409/C should be quoted.

Applications from abroad should be forwarded by airmail.

E9172 A

FIRST CLASS DRAUGHTSMAN required East Anglia. Experienced General Engineering and Mechanical Handling. Good technical training and able to work with minimum supervision. Flat available if required. First class conditions. Superannuation.—Apply, stating age, experience and salary required to Technical Director, BOX No. E9142, "The Engineer." A

GENERAL ENGINEERING DRAUGHTSMEN (Senior), having experience in Machine Design and Works Layouts. A knowledge of works building design desirable but not essential. Technical education to at least O.N.C. Some assistance will be given with regard to house purchase in cases of successful applicants who are married.—Write, giving details of experience and stating age and present salary, to the Personnel Manager, FERODO LIMITED, Chapel-en-le-Frith, Via Stockport. E9185 A

GENERAL FOREMAN MACHINE SHOP AND TOOLROOM

A well-known engineering company in the West of Scotland are, at present, undergoing internal reorganisation to improve their facilities and equipment prior to expansion.

There is a vacancy for a General Foreman to manage the machine shop and toolroom, and applications are invited from suitable candidates not over 40 years of age, who must possess initiative and who are seeking a position with prospects for promotion.

Preference will be given to those with proved organising ability, a sound technical training and the capability of retraining and instructing adult operators.

Contributory pension and free life assurance schemes in operation.

Reply, giving full particulars of previous experience in chronological order, together with details of technical training.—BOX No. E9250, "The Engineer." A

GOOD TOOLMAKER MECHANIC REQUIRED for Zip Fastener manufacturers. Salary £17 10s.—Write details to BOX No. E2197, "The Engineer," or 'phone REG 3516. A

MAINTENANCE ENGINEER required for heavy chemical works in East London. Experience with planned maintenance procedures desirable. Age 30/45. Staff superannuation and profit-sharing schemes.—Write, BOX Z.S.596, Deacons Advertising, 36, Leadenhall Street, E.C.3. E9235 A

MECHANICAL AND CIVIL ENGINEERING DRAUGHTSMEN required for a drawing-office engaged on all types of work connected with mining, quarrying, hydraulics and industrial building construction. A superannuation scheme is in operation.—Application, stating qualifications, experience and salary required, should be made to The Chief Engineer, MESSRS. ENGLISH CLAYS LOVERING POCHIN AND CO., LTD., 14, High Cross Street, St. Austell, Cornwall. E9272 A

MECHANICAL ENGINEERS required for highly interesting new design and development work in the field of Converting Machinery for Paper and Board. Previous experience in this field, though desirable, is not essential but successful candidates must have solid academic and practical engineering background with sound knowledge of design, and be able to produce as well as evaluate new ideas. Modern works in S.W. London. Pension scheme. Good salary.—Applications, which will be treated in confidence, should include full particulars of training and experience.—Reply BOX No. E9174, "The Engineer." A

PRODUCTION MANAGER

required by

large heavy engineering establishment, Glasgow, to be responsible for all methods of production, ratefixing and time study. Preference will be given to candidates who have a wide experience with production methods in light fabricated steel structures. Reply, stating full details of training and experience. Salary £2000 to £3000, depending on experience and ability.

BOX No. E9248, "The Engineer."

A

PROJECT ENGINEER

An opportunity is offered to a First-Class Project Sales Engineer in a large, old-established Midlands engineering company. The duties are in connection with controls schemes embodying hydraulic and pneumatic equipment and covers complete quotations. The applicant should be experienced in sales and outside Customer contacts.

BOX No. E2199, "The Engineer."

A

QUALIFIED CIVIL ENGINEER required by Consulting Engineers, for position of ASSISTANT RESIDENT ENGINEER, to supervise construction of Port Works at Port Sudan. Salary according to experience and qualifications, married quarters available with heavy furniture, cost-of-living allowance and bonus. Duration about sixteen months.—Write, stating age and experience, to COODE AND PARTNERS, 2/8, Victoria Street, London, S.W.1 E9192 A

QUALIFIED STRUCTURAL ENGINEER required for precast concrete structure specialists based in S.E. England. Knowledge and experience of this type of work essential. The position offers scope for initiative, keenness and ambition and is suitable for a first-class engineer who wishes to work as an individual within a large organisation taking responsibility for own work.—BOX No. E9260, "The Engineer." A

RESEARCH ENGINEER with University degree and some workshop experience required for two or three years' experimental work into the stresses in steam pipework, with particular reference to advanced steam conditions. Previous training in research an advantage but not essential. Salary £600–£750 per annum with superannuation, according to age and experience.—Applications, with full details to Professor H. Ford, Mechanical Engineering Department, Imperial College of Science and Technology, London, S.W.7. E9264 A

RESEARCH ENGINEER

A vacancy exists in the Oil Seal Division of George Angus and Co., Ltd., for a qualified ENGINEER to work on fluid sealing problems. Applications are invited from men with initiative and ability, with B.Sc. Degree in Mechanical Engineering, and who have had workshop training in fitting and machine shops, together with several years' industrial experience in design development or research. Actual experience in fluid sealing is not essential. This post, which is located in a modern, well-equipped factory, carries attractive staff conditions, including superannuation and bonus schemes, and consideration towards housing assistance.—Written applications should be sent in confidence to the Personnel Manager, GEORGE ANGUS AND CO., LTD., Oil Seal Division, Coast Road, Wallsend, Northumberland.

E9237 A

SCIENTIST required at the NATIONAL COAL BOARD'S MINING RESEARCH ESTABLISHMENT, WORTON HALL, ISLEWORTH, MIDDLESEX, to take charge of a group investigating the factors governing the successful working of coal seams by coal ploughs and allied machinery. The work will embrace both laboratory experiments and field trials. Good Honours Degree in Physics or Mechanical Engineering required. Appointment superannuable and salary according to qualifications and experience would then scale £1487–£1964 (male).—Write for application forms to the Personnel Officer (X1318D) at the above address, which should be returned by the 10th of December, 1958. E9271 A

TECHNICAL ASSISTANTS required for work on aerodynamic problems, associated with the design of propellers, air turbines, flow control systems, &c., for advanced aircraft projects, including V.T.O.L. types. Applicants should be of Degree standard.—Reply to the Personnel Manager, Rotol Limited, Gloucester. E9279 A

SENIOR CIVIL ENGINEERING ESTIMATOR required for national firm of Building and Civil Engineering Contractors, at their Edinburgh office. Applicants, aged 35 to 50, should have wide experience of tendering for large civil engineering contracts. Salary according to qualifications and experience and the position offers scope for advancement to the right person. The company operates a contributory pension scheme.—Write, giving full particulars, salary required, and quoting reference CV.1.1/324/58, to Secretary, Holloway Bros. (London), Ltd., 157, Millbank, S.W.1. E9280 A

STAVELEY RESEARCH DEPARTMENT

The following two vacancies exist in the Staveley Research Department :—

(1) An ENGINEER, with predominantly a MECHANICAL background and an Honours Degree in Science or Engineering.

The successful candidate would fill a senior post in a new research organisation associated directly with an important basic industry whose advancement is vital to the national economy.

Applicants should be interested in both directing and carrying out experimental and theoretical investigations on the dynamics of mechanical or hydraulic systems.

The work is ultimately concerned with the introduction of automatic control and application of advanced technology to machine tools. This will involve a complete reassessment of their fundamental structural and transmission characteristics, and candidates with previous experience either on vibration problems or control systems would find this experience invaluable.

A salary up to £1400 p.a. is envisaged for this post.

(2) A GRADUATE ENGINEER, to work on automatic control systems, and electro-mechanical devices.

Preferable experience would be in one or more of the following :—

(a) System synthesis and analysis.
(b) Design and development of electronic control circuits.
(c) Design and development of electro-mechanical elements.
(d) Measuring techniques.

Both posts carry attractive superannuation conditions.

Please apply :
The Director of Research,
Staveley Research Department,
Clapham, BEDFORD.

E9247 A

TECHNICAL ASSISTANTS.—Applications are invited from young Engineers or Technicians to assist in the development of an industrial engineering division. Applicants should have experience in dealing with the technical problems of operational analysis and methods as applied to one or all of the following: Machine shops, fabricating and erection departments of a medium/heavy engineering industry. Qualifications H.N.C. (Mech.) minimum or equivalent. Age 25/35. Attractive and interesting appointments.—Applications in writing, with relevant details in confidence, stating approximate salary required, to Personnel Manager, Ruston-Bucyrus, Ltd., Excavator Works, Lincoln. E9244 A

THE MOTOR INDUSTRY RESEARCH ASSOCIATION

Applications are invited from GRADUATE ENGINEERS with research experience for a senior post in a modern and well-equipped Engine Laboratory engaged on applied research for the motor industry. Salary in range £1500–£1750 p.a. according to experience; Superannuation Scheme.

Applications, giving full particulars of qualifications and experience, to be addressed to Director, the Motor Industry Research Association, Lindley, Nr. Nuneaton, Warwicks.

E9265 A

WORKS SUPERINTENDENT

required for factory in the West of Scotland, at present engaged in light mechanical and structural engineering.

Candidates, preferably between the ages of 35 and 40 years, should be conversant with modern management techniques and control systems. The successful candidate must be a sound production engineer, with a good technical background and knowledge of modern developments in the manufacturing field. He must be able to delegate responsibility to his subordinates. Preference may be given to candidates with previous experience, which includes light electrical production techniques, and who are members of the Institution of Production Engineers or a similar professional body.

Contributory pension and free life assurance schemes in operation.

This position gives scope for further advancement with an expanding organisation.

Reply, giving full particulars of previous experience in chronological order, together with details of technical training.—BOX No. E9251, "The Engineer." A

WORKS ENGINEER required by a well-established paper converting company in North-West London. Candidates should be between the ages of 30 and 40. They should have a sound practical experience of mechanical engineering and a good working knowledge of steam and electrical services. Salary will depend on experience and qualifications, but will be in the region of £1000 a year. Apply at first in writing, giving details of previous experience.—BOX No. E9263, "The Engineer." A

MSL have been retained to advise on the appointment of an

INDUSTRIAL ENGINEER

for the factories in Northern Ireland of a company engaged in the food processing industry.

The Industrial Engineer will be responsible to the Financial Controller for investigating and advising on production methods, for establishing time standards and job specifications, for labour cost control procedures including incentive schemes and for setting cost standards in three factories.

Applicants should be qualified in either cost accounting or engineering and must have been trained in modern work and method study procedures and techniques. Experience of canning processes in the food industry is particularly relevant but is not essential.

Initial salary £1,400 plus car. Preferred age 35 to 40.

No information will be disclosed to our clients until candidates know their identity and have given permission after personal discussion. Please send brief details in confidence, quoting reference G.1355, to G. K. Dickinson.

MANAGEMENT SELECTION LIMITED
17, Stratton Street, London, W.1.

E134 A

WORKS MANAGER

Applications are invited for the appointment of Works Manager with a well-known company in Surrey (London fringe) engaged in the manufacture of machines and equipment for the Plastics Industry.

Candidates—between 35 and 45—must have passed a satisfactory mechanical engineering apprenticeship and have progressed to a position of responsibility, preferably as Works Manager or Production Manager.

The post offers excellent prospects to a man with ability to organise and maintain economic production, and the successful candidate will be directly responsible to the General Manager.

All applications will, of course, be treated in confidence.

Please write, giving age, experience, qualifications and salary required.—BOX No. E9241, "The Engineer." A

STOTHERT & PITT LTD., ENGINEERS, BATH.

A vacancy exists for a DESIGNER experienced in the development of CONCRETE MIXERS and BATCHING PLANTS. Good salary according to experience. Excellent prospects. Age about 28/34 years.

Apply in writing to Chief Engineer, Contractors' Plant Department, Stothert and Pitt, Ltd., BATH, Somerset.

E9259 A

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Applications are invited from Mechanical Engineers to join a Team engaged on development work for Plants operating at low temperatures.

The work offers considerable scope to Engineers who wish to enlarge their experience in new fields of endeavour, and will involve the design of new processes and components, including pressure vessels, various types of machinery and heat exchangers.

Qualifications to the standard of a good Degree or equivalent are required and/or previous experience on plant development work.

Excellent salaries and conditions of service are offered and assistance with HOUSING may also be given.

Applications, giving full details, should be sent to :

Employment Officer, (E/C. 1184)

BRITISH OXYGEN ENGINEERING LIMITED

Angel Road, Edmonton, London, N.18

E9266 A

SITUATIONS VACANT

ENGINEERING DRAUGHTSMAN

with O.N.C. or H.N.C. in Mechanical Engineering and good general experience in factory service plant and production plant layout and design, required for London Office.

5-day week, contributory pension fund, excellent working conditions and canteen facilities.

Apply in writing, giving age, experience, qualifications, salary required, to :—

The Secretary,
Associated Electrical Industries Overseas, Ltd.,
33, Grosvenor Place, London, S.W.1.

E9252 A

PATENTS

THE PROPRIETOR OF BRITISH PATENT NO. 734,918, entitled "REMOVABLE ARCH SECTIONS FOR INDUSTRIAL HEATING FURNACES," offers same for Licence or otherwise to ensure practical working in Great Britain.—Enquiries to Singer, Stern and Carlberg, 14 E, Jackson Blvd., Chicago, 4 Illinois, U.S.A. E9194 H

THE PROPRIETOR OF BRITISH PATENT NO. 715,619, entitled "Metal Working Machines and Optical Projection Apparatus Therefor," offers same for Licence or otherwise to ensure practical working in Great Britain.—Inquiries to Singer, Stern and Carlberg, 14, E. Jackson Boulevard, Chicago, 4, Illinois, U.S.A. E9238 H

BRITISH PATENT NO. 731,302.—"IMPROVEMENTS IN A PROCESS FOR THE PRODUCTION OF CHAINS." Owners desire commercial exploitation on reasonable terms by Licence or Sale. —Enquiries : H. D. FITZPATRICK & CO., Chartered Patent Agents, 94, Hope Street, Glasgow, C.2, and 3, Gray's Inn Square, London, W.C.1. E9276 H

FOR HIRE

LATTICE STEEL. Erection Masts (light and heavy), 30ft. to 150ft. high, for immediate hire.—Bellman's, 21, Hobart House, Grosvenor Place, S.W.1. ('Phone SLOane 5259). E103 K

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E9267 A

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MANAGING DIRECTOR RETIRING invites applications from qualified Engineer with technical and/or commercial experience and finance to purchase major shareholding.—BOX No. E2178, "The Engineer." O

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CASTINGS.—We can save your porous castings, ferrous or non-ferrous, by an approved impregnation process ; sample castings treated ; A.I.D. approved. —Recupero, Ltd., 66, South Harrow Viaduct, Harrow, Middlesex ('Phone, Byron 1178). E109 MW

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GRAD. I.C.E. (32, married) seeks Overseas Post about June. Experience includes civil design for major refinery and chemical works, also some marine work. Four years Trinidad oilfield in charge of civil work and transport. Due U.K. April.—"Engineer," c/o Royal Bank of Canada, Point Fortin, Trinidad. E2201 B

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E9249 L

Classified Advts. continued on page 120

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E9199 G

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E105 G

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December 2–3	**Machine tools and miscellaneous stores,** including textiles, binoculars, Nissen hut components, etc.	M.O.S. Storage Depot, **Byley, Middlewich, Cheshire.** (Sale at New Islington Public Hall, Ancoats, Manchester.)	**J. H. NORRIS & SON,** (Dept. L), 9, Albert Square, Manchester, 2. (Tel.: Blackfriars 8373.)
December 5	**Miscellaneous stores.**	Returned Stores Group, Reed Hall, **Colchester, Essex.**	**FENN, WRIGHT & CO.** (Dept. L), 146, High Street, Colchester, Essex. (Tel.: 3171.)
December 9	**Miscellaneous stores,** including:	M.O.S. Storage Depot, **Ruddington, Notts.**	**WALKER, WALTON & HANSON** (Dept. L), Byard Lane, Bridlesmith Gate, Nottingham. (Tel.: 47271.)

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December 15–19	**Miscellaneous stores.**	M.O.S. Storage Depot, **Royal Arsenal, Woolwich, S.E.18.**	**FULLER, HORSEY, SONS & CASSELL** (Dept. L), 10, Lloyd's Avenue, London, E.C.3. (Tel.: Royal 4861.)
1959 January 8	**Miscellaneous stores.**	General Stores Sub Depot, **Longtown, Near Carlisle.** (Sale at County Hall, Carlisle.)	**HARRISON & HETHERINGTON, LTD.** (Dept. L), Botchergate, Carlisle. (Tel.: 26292.)

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E118 J

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4¼in.	× 3¼in.	2ft. 9in.	79
4in.	× 2 ⅝in.	2ft. 9in.	512
3¼in.	× 2¼in.	2ft. 10¼in.	762

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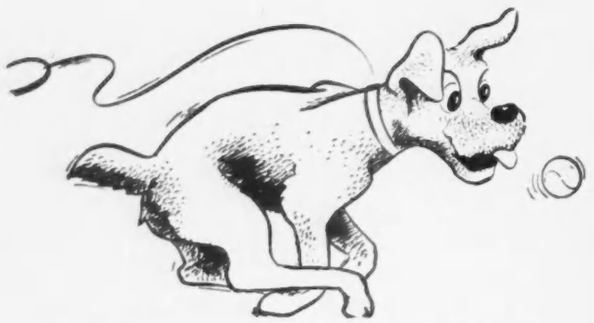

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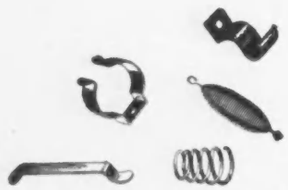

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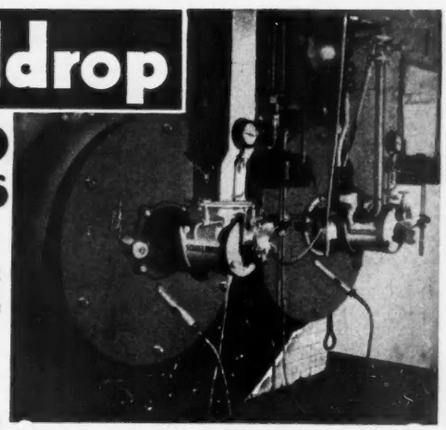

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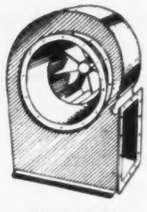

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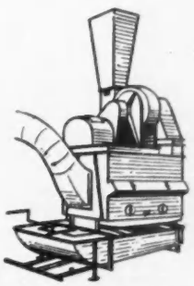

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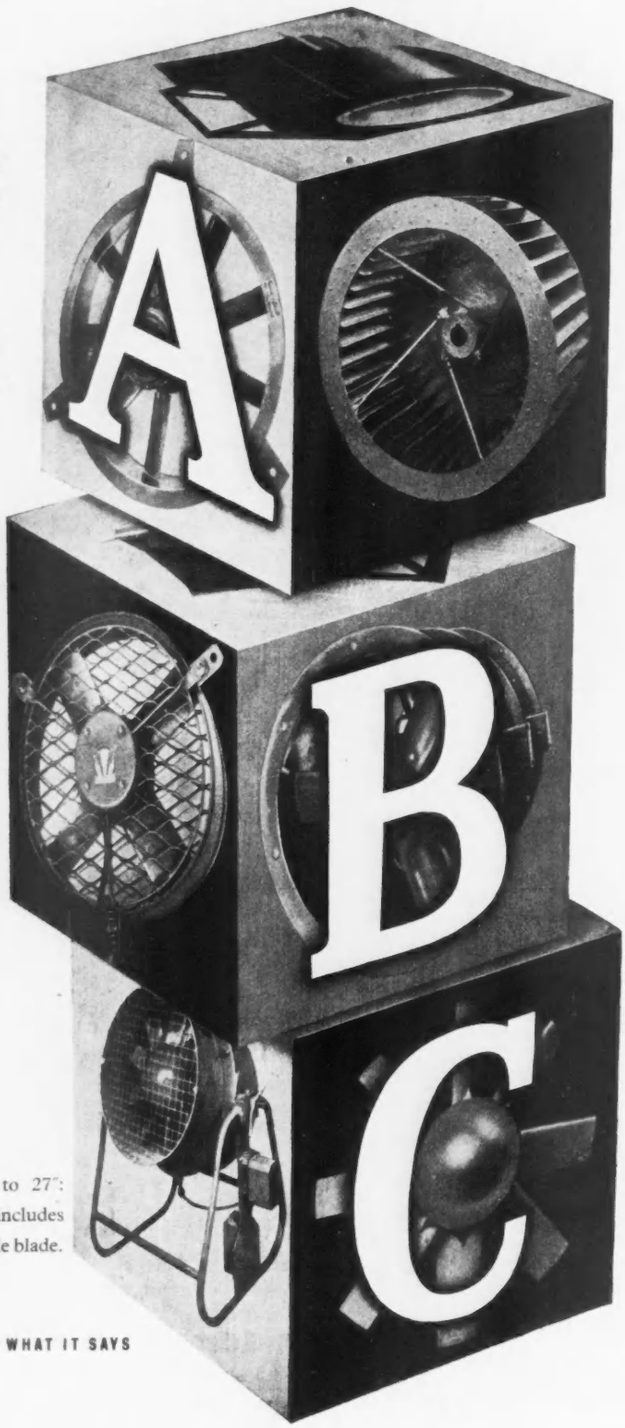

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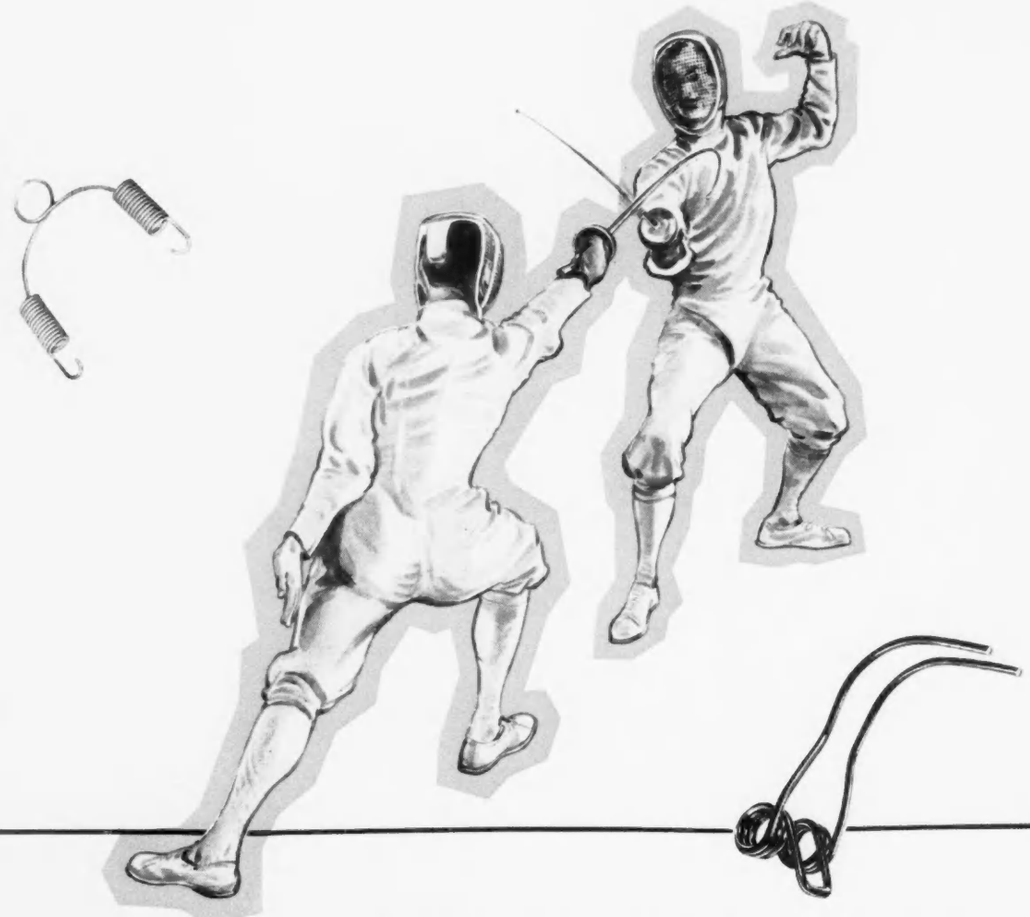

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